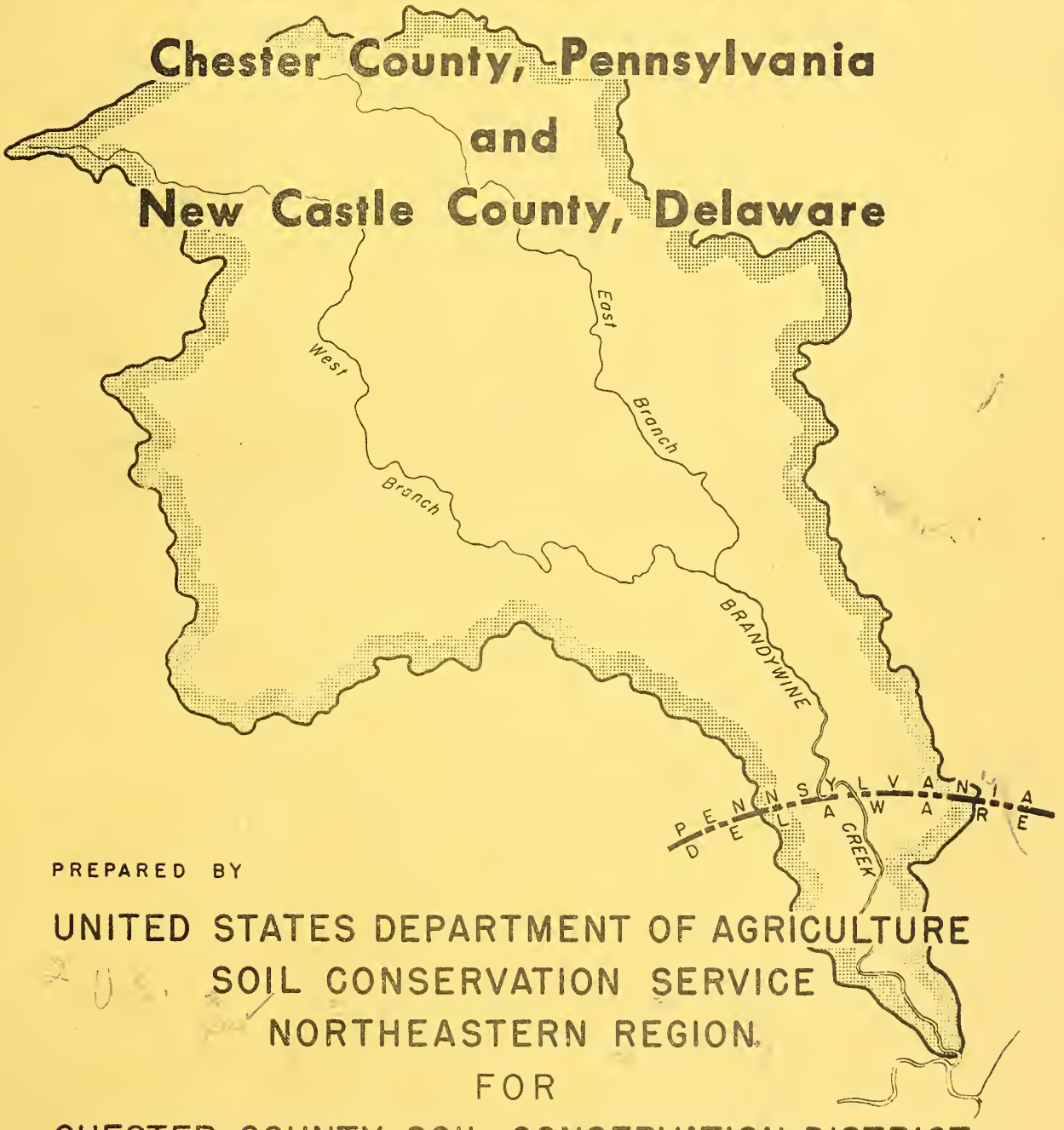
COMMUNITY WATERSHED SOIL AND WATER CONSERVATION WORK PLAN FOR BRANDYWINE CREEK

Chester County, Pennsylvania and New Castle County, Delaware



PREPARED BY

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NORTHEASTERN REGION

FOR

CHESTER COUNTY SOIL CONSERVATION DISTRICT
AND
NEW CASTLE COUNTY SOIL CONSERVATION DISTRICT

AGR-SCS-UPPER DARBY, PA.

JANUARY, 1952

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THE BRANDYWINE -- A COMMUNITY WATERSHED

A new kind of community has been recognized in the Brandywine Valley. It is made up of cities like Wilmington, Coatesville, West Chester, and Downingtown, and smaller towns like Exton, Chadds Ford, and Honeybrook. It is made up of farms, some large, some small. The new community embraces 200,000 people, young and old, from every walk of life. The responsibilities in this community are shared alike by the industrialist, the businessman, the farmer. School children have a stake in its success. Those yet unborn may have an even greater stake.

This new community is the Brandywine Watershed itself, the drainage area of Brandywine Creek and the scores of smaller streams feeding into it as it flows toward the mighty Delaware. Physically, the watershed is simply the basin where rain and snow water are collected. In total, the watershed is much more than that It is a tangible, living area with character and dimensions. It affects and is affected by the people who live in it.

The community itself is not new. It has existed for centuries as a unit of nature, bound together in an interrelationship of soil, water, climate, and plant and animal life. It is governed by natural principles, such as the law of gravity and the movement of soil by running water. But what is new is the development by the people of a community consciousness in their Brandywine watershed--a realization that the watershed itself is no more abstract or theoretical than the mapped areas of towns and counties. It is an awakening to the fact that efforts to use, conserve, or develop natural resources without regard for the watershed and natural principles would be costly and likely to fail.

For generations, everyone took the Brandywine for granted. Its resources seemed boundless; its permanence went unchallenged. More and more of the forests were cleared for farm crops. More and more factories and towns crowded upon the streambanks. More and more people claimed the water and land for hundreds of varied uses.

Gradually, there were disquieting signs of change. Floods came at more frequent intervals, reached higher, and caused damages at increasing rates. Gullies began to scar the cropland. Good soil piled up at the foot of cultivated slopes after every rain. Fish disappeared from the watercourses as mud clouded the water, warmed it, and killed plant life. Dam sites and reservoirs were filled with sediment washed off the land.

It became obvious that life on the Brandywine could not go on in the old carefree manner. Silt clogging the shipping port at Wilmington was an increasing source of expense and nuisance. Rising costs caused by flood and sediment damage to water supplies, highways and industry called for action. Farmers saw their operating expenses rise as vast amounts of productive soil washed away. Sportsmen and nature lovers became aroused over growing threats to fish and wildlife and diminution of the valley's over-all natural beauty.

A TASK TO SHARE

As people thought about the various problems, the inescapable interrelationships in solving them became clear. Erosion, floods, sediment and pollution struck at every citizen alike. Conservation measures applied to the valley bottoms could be made useless by the lack of them higher up on the slopes. Larger and more expensive water treatment plants could be nullified by failure to control sediment pollution at its source on the land. Increasingly elaborate attempts to improve hunting and fishing would avail nothing if fish and wildlife habitat were in process of destruction. Thus the farmer and town-dweller began to note their mutual interests. Saving the watershed depended--literally--upon everyone who used it.

In the face of a common problem, a community spirit was fostered. From Wilmington to Loag's Corner and from West Chester to Parkersburg people began to talk over the need for a Brandywine watershed program. The Brandywine Valley Association

formed an organization of hundreds of business, civic and agricultural interests. Its officers talked tirelessly to countless farm, social, fraternal, school and legislative groups--clarifying their stories with slide photo projections of critical features of the watershed. Soil and water conservation specialists became more and more frequently invited to meetings of valley citizens.

DISTRICT LEADERSHIP RECOGNIZED

Early in the movement, the leadership of the local soil conservation districts was brought into play. The New Castle County District of Delaware helped stimulate public interest in the development of a watershed conservation plan for the Brandywine through their effective soil conservation work with groups of farmers. Their program, and the educational efforts of the Brandywine Valley Association, gave impetus to the organization of the neighboring district in Chester County, Pennsylvania. The districts, organized under State laws, were authorized to do much of the farmland treatment called for by Brandywine problems. Working with farmers whose lands encompassed the bulk of the watershed, the districts had, in addition, the technical help of the U. S. Soil Conservation Service, an agency that has specialized in soil and water problems for more than 15 years.

SURVEY RECOMMENDATIONS

At the request of the soil conservation district leaders, and the Brandywine Valley Association, the Soil Conservation Service, working with the local people, has developed recommendations for a watershed treatment program, which is now laid before the valley residents.

The program is aimed primarily at controlling erosion and floods where they originate on unprotected land. Emphasis is placed on more extensive cover-cropping of cultivated areas and protective crop rotations. Better land use and practices that protect soil and water resources, such as contour strip cropping, diversion terraces, perennial hay, tree planting and management are recommended.

All recommended measures are geared to maintain the over-all production of agriculture while increasing per acre yields. Acre by acre studies of the watershed would in some cases form the basis for new farm enterprises and markets.

The survey delves into greater opportunities for recreation in the valley. Hundreds of artificial ponds for bathing and fishing as well as for farm uses are recommended. Sites for large bodies of water are suggested. Hedge and shrub plantations to attract wildlife are detailed along with potential wildlife cover zones near farmed fields and woodlots. Several areas for waterfowl and fur-bearer habitat are also outlined.

Special attention has been directed to the flood alleviation aspects of the program. With a firm base of land treatment designed to convert raindrops to man's use with minimum damage or waste, additional measures have been indicated. Streambank engineering and diking are itemized and described. All factors are discussed in the light of costs and expected benefits in dollars and cents. Estimates show the whole job could be accomplished in 10 years and would pay for itself in the space of 12 years. Proper maintenance of the program would keep the Brandywine useful well into the foreseeable future.

A TIME FOR DECISION

This Work Plan might be termed a blueprint for community action to solve the related ills of Brandywine watershed lands. It can be carried out only through the active and intelligent participation of watershed residents. As citizens in a democracy, they own the property, control the institutions, and determine what activities shall be acceptable in their community. They are the ones called upon to pay directly and indirectly for some part, large or small, of the proposed watershed improvements. Unless they participate in the program personally, and in organized groups

within the watershed community, little lasting good can be accomplished.

The time for decision has arrived. Government can, by aid and guidance, encourage the action that is needed. It can supply technical assistance. But the people themselves must develop and carry on the program.

Early records indicate that the Indians left the Brandywine Valley to the white settlers with considerable reluctance. Anyone who has seen the area can readily understand this. Great changes have come in the past 300 years: farms and homes have replaced much of the virgin forest. Important industries sit astride the once quiet-running waters. Busy lanes of modern commerce criss-cross the sites of ancient red men's trails.

Yet much of the primeval beauty remains. The rolling fields of the present-day farms, the shaded streets of the towns and the bolder vigor of the cities lend their own peculiar tones of interest to the region. And something of the Brandywine's part in America's past and present strength is everywhere in the atmosphere. Only yesterday, it seems, Washington's gallant farm lads fought for the vital fording places around Chadds Ford. Today, from 300-year old Wilmington, ships of the seven seas take the valley's processed goods to the far corners of the world; or bring in materials to be submitted to the skills, ingenuity and resources for which the valley is renowned.

The valley hills once echoed to the rumbling of pioneer wagons heading for the new lands in the South and West. Nowadays, the Pennsylvania Turnpike cuts across the upper East Branch. The Pennsylvania Railroad's New York-Chicago line passes through the northern part of the watershed; the New York-Washington route goes through Wilmington, as does the New York-Baltimore run of the Baltimore & Ohio. The Reading Railroad follows the Creek throughout much of its length. In addition, there is ample, local commuter and freight service.

THE WATERS

Brandywine Creek and its tributaries drain an area of about 330 square miles, or 211,200 acres. The watershed is roughly funnel-shaped, with the broad inlet end lying largely in Chester County, Pennsylvania, with small portions also in Delaware and Lancaster Counties. The neck of the funnel is a six-mile strip running through New Castle County in Delaware. The trend of the entire system is northwest to southeast. Its greatest length is 36 miles, air distance; its greatest width is 21 miles.

The more than 570 miles of streams in the Brandywine system give the watershed a relatively high drainage density. The two main tributaries, the West and East Branches, course 33 and 24 miles respectively before uniting to form the mainstream near Lenape a few miles south of West Chester. From that point it is only 18 miles south to where the Brandywine joins the Christina River at the city of Wilmington's marine port on the Delaware River.

Notable, even to the casual visitor, is the watershed's diverse topography. The land surface is far from uniform. Authorities attribute this to the violent geologic history of the section. There are evidences of several eras of upheaval, cracking, folding and sinking in prehistoric times. The shifting, wandering and cutting action of the river system itself has contributed further disunity to land formations.

Sources of both the West and East Branches are springs in the Welsh Mountains, 960 to 1040 feet above sea level. Headwaters of each are only a mile apart. Early mills were attracted to the waterpower potential of both branches--particularly the West. Upper portions of streambeds drop swiftly--as much as 33 feet per mile. Most mill and dam sites on the East Branch are concentrated above Downingtown. They are common throughout the length of the West Branch.

Prominent feeders to the West Branch are Two Log, Reese, Birch, Northern Birch, Rock, Sucker and Buck Runs. Contributing to the East Branch-Beaver, Marsh, Indian, Spring, Taylor, Perkins, Dennis and Black Horse Creeks are among the most significant. Pocopson Creek is an important tributary of the lower Brandywine.

After the first rush through the northern uplands, stream gradients become gentler especially where they pass across the broader, flatter section called Chester Valley. Almost everywhere the stream environs are characterized by narrow, flood

plains. However, as the mainstream approaches Wilmington at the Delaware-Pennsylvania border it begins to cut through low headlands in a meandering series of sweeps that are almost gorge-like in nature.

THE LAND

More than 150,000 acres (three-fourths of the area) in the watershed are in farm lands. The farm population is about 8,000, occupied with nearly 1,500 farm enterprises. Dairying is the main source of revenue, as evidenced by the 25,000 head of cattle, although beef raising is a growing trend. The productivity of the valley is also noticeable in the over-all average of 50 bushels of corn per acre. Wheat and barley are important winter grains. Three percent of the land in farms is occupied by buildings, with about 12 percent of the land in farms not in use for any particular form of production.

Ready markets exist at easily reached centers in Philadelphia, Lancaster, Baltimore and Wilmington.

Land operations are favored by the local soils and climate. The former are generally described as good for farming. They are medium textured, fertile and well watered. The best soils are in the limestone based Doe Run section and Chester Valley. The weather is of a continental type, considerably modified by the nearby ocean. The year-round precipitation is usually in the neighborhood of 45 inches, 25 inches of which are available during the growing season.

Anywhere from 10 to 30 inches of the precipitation annually runs off down the streams and into the sea. However, the watershed averages less than 100 days of frost and the temperature seldom dips below zero. Rarely, for example, does the port of Wilmington have difficulty with ice.

More than 45,000 acres--22 percent of the terrain--are forested, with tulip poplar, white and red oaks the dominant species. There are 4 school forests and 12 tree farms cooperating with the Pennsylvania Department of Forests and Waters. It has been estimated that the average woods growth rate on the watershed amounts to an average one cord per acre year.

Although the Brandywine has a large population, Wilmington and its suburbs account for more than half. Thus the countryside in general remains charmingly rural in appearance. This sets up a competition enhancing the values of watershed land. There is a growing tendency for real estate development pressed by the swiftly expanding populace of the readily accessible cities and larger towns. In short, all factors relating to the Brandywine are dynamic and susceptible to swift change. The future of the area--for better or for worse--hangs in the balance.

HUNTING AND FISHING

Of no minor noteworthiness are the outdoor sports and other recreational resources of the Brandywine. There are several sportsmen's associations--all active and interested in the watershed conservation movement. Thousands of hunters and fishermen - many from the nearby large cities - take advantage of the local facilities. Corn and small grain on the farms afford forage for game and the scattered woodlots give wildlife cover.

Fishing is largely on a "put and take" basis at present--an occasional bass, plus perch, sunfish and catfish being the usual catch in most of the waters. Brook, brown and rainbow trout are stocked in the northerly waters. Fishing intensity (number of fishermen per mile of stream) is about one-third the state average. This may be the reason that fishing success on the Brandywine is approximately the same as the state-wide average--in numbers of fish caught per man-hour of angling.

Ten thousand acres are maintained as cooperative game farms. The shooting bag in sample areas has been quite respectable in recent years. In 1950, for example, one 2,097 acre game project produced 1,700 rabbits, 950 pheasants, 300 grey squirrels, 200 woodchucks, 300 waterfowl and 3 deer. Generally speaking, bobwhite quail is the only species of small game on the downward trend. Other game--especially deer, fox,

Dairying is the main source of revenue on farms of the watershed.

More and more beef cattle are being raised on the grassland farms of the Brandywine.

raccoon and muskrat--give some indications of approaching nuisance proportions.

The inviting fields, forests and waters of the Brandywine and the wildlife they support are assets of genuine value. They are entitled to their full measure of consideration in the program to secure a permanent usefulness for the watershed.

Even the non-professional observer is aware that all is not as it should be with the Brandywine. The townsman knows of the floods--seeing them personally, or reading of them in his newspaper. The farmer sees his lands inundated at intervals and feels the pinch in his pocketbook when valuable soil washes downstream. The manufacturer knows what it costs him to repair or replace water-damaged supplies or machinery and installations. The city of Wilmington can report what is spent to keep its harbor free of silt.

However, a technical survey of all the watershed's problems has been made, in order to arrive at specific recommendations.

Erosion in its various forms--but always indicative of lost topsoil--is a prime difficulty along the Brandywine. It is associated with unstable water runoff. It has resulted from insufficient information on the capabilities of the land and the value of sound soil and water conservation practices.

EROSION

Sheet and gully erosion are moving soil at the rate of approximately 3½ tons per acre each year. Stream and roadbank erosion are accounting for a minor share of gross soil losses. Altogether, it is estimated that the Brandywine watershed experiences the shifting of nearly 800,000 tons of soil annually. The following table reveals erosion losses by types:

Table 1. Estimated Gross Erosion
Brandywine Creek Watershed

Type of Erosion	Tons Per Year	Percentage
Sheet and Gully Erosion	760,900 1/	95.3
Streambank	34,580	4.3
Roadbank	3,120	0.4
TOTAL	798,600	100.0

1/ Based on a weight of 85 pounds per cubic foot for dry soil in place.

It is interesting to note that cropland here as elsewhere is the prime target for erosion. This is understandable as cultivated lands are most often exposed to the inroads of wind and rain. Table 2 shows the amount of erosion occurring annually on land according to each acre's present use.

Table 2. Estimated Annual Soil Losses
Due to Sheet and Gully Erosion
Brandywine Creek Watershed

Present Land Use	Acres	Annual Loss in Acre-Feet*	Percent
Cropland	72,241	361	90.9
Pasture	36,154	15	3.8
Woodland	45,225	6	1.5
Idle Land	35,181	14	3.5
Homesteads Urban Roads, Water, etc.	22,399	1	0.3
TOTAL	211,200	397	100.0

* 1 Acre-Foot--1,849 Tons.

EROSION CONTROL. The sweeping effect of conservation methods of land treatment, land use conversions and specialized additional measures is evident in the calculation that local erosion would be thereby reduced 86 percent. Treatment work would be applied largely to sloping, cultivated land and would include management of crops, pasture and woodland. This would be supplemented by conversions in land use--particularly, the transformation of steep, seriously eroding cultivated and pasture areas into tree plantations. With the latter expedient, erosion would be greatly decreased on 1,600 acres of precipitous pastureland, on 5,400 acres of idle and miscellaneous farmland and 12,000 similar acres of nonfarmland.

Diversion of water from critical areas, and stabilization of gullied lands by vegetative and mechanical means, would markedly reduce erosion and prevent the beginning of new gullies.

STREAMBANKS. There are approximately 33 miles of streambank needing some erosion control. The type of treatment required varies with the severity of cutting and height of bank, and involves such measures as sloping, planting, fencing and riprap in various combinations. It is estimated that approximately 4 miles require sloping and some riprap while most of the remaining 29 miles need only planting and protection from grazing, or, in some cases, only protection. The need for protection from grazing could be met by planting multiflora rose along the top of the bank. Where riprap is needed to protect the toe of an eroding bank, heavy angular stone should be used.

The quantity of material washed and cut away from streambanks can be reduced 50 percent using the above methods.

ROADBANKS. Roadbank erosion includes all losses of soil as a result of earth movement produced by the building of roads and from inadequate maintenance. Most of the roadbanks in the Brandywine Watershed are well vegetated and are considered a minor source of sediment. The erosion occurring is usually located on banks or in ditches recently constructed where vegetation has not been established.

WOODLAND

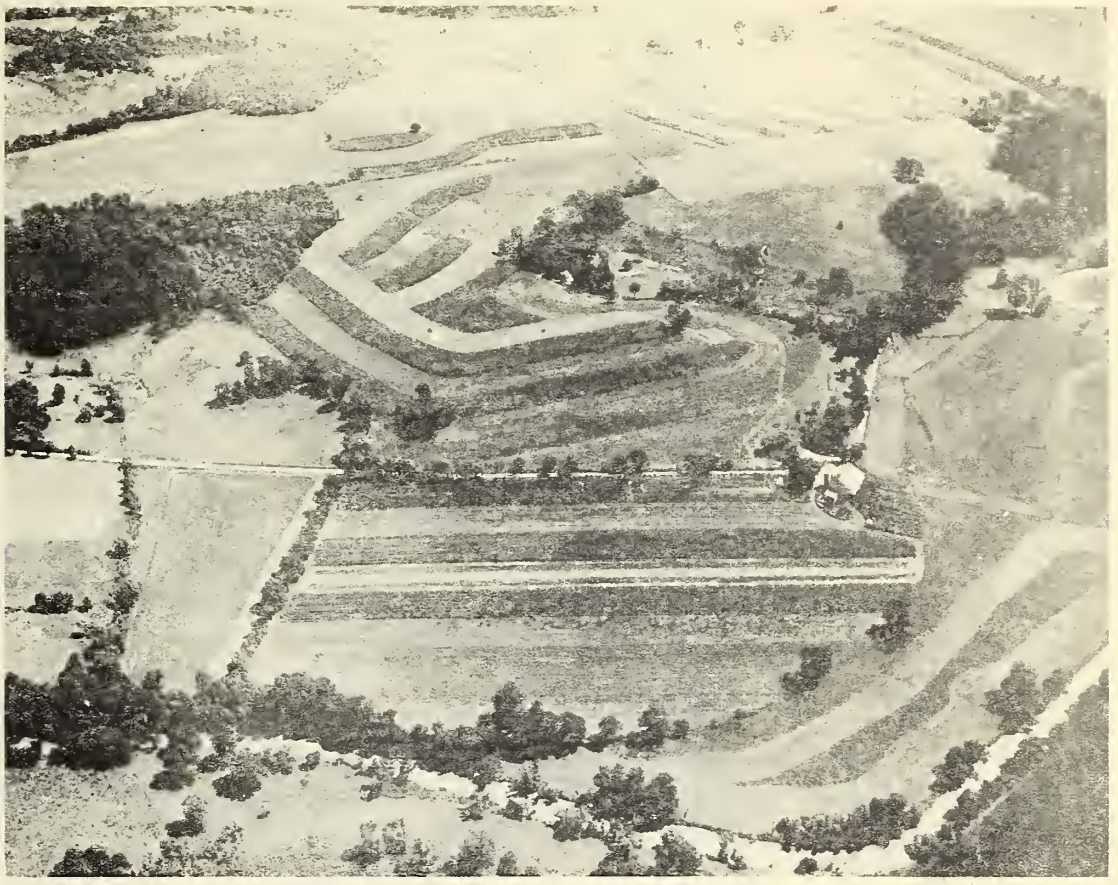
The forests and woodlots of the watershed deserve special mention. The watershed conservation program calls for considerable increases in such areas. Over 54,000 acres would be involved ultimately in improved management, harvesting and planting. As indicated, trees have the desirable characteristics of "steadying" water resources and defending against soil wash. Not to be overlooked is the prospect of a larger revenue from the valley's timber industry.

It is estimated that tulip poplar and oak are growing at the rate of from 300 to 600 board feet per acre year. Where tulip poplar is a minor part of the woodlot, maximum growth rate is estimated to be 250 board feet per acre year. Oak growth rate is estimated to be from 140 to 500 board feet per acre year. The average growth rate here is 70 cubic feet, or about 1 cord per acre year.

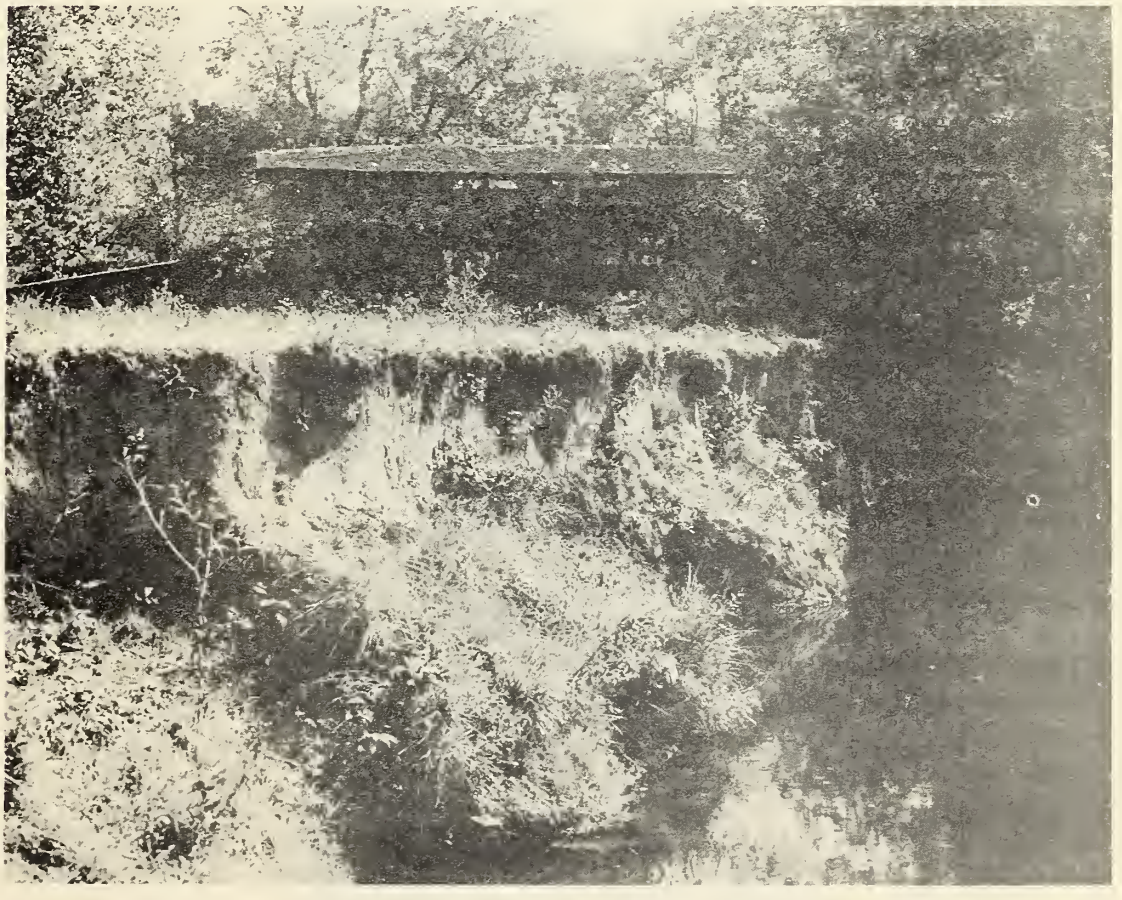
There have been no large forest fires in recent years. On the average there are 11 brush fires reported annually. The average number of acres affected per fire is 12. The State maintains an effective fire detection and suppression system. Fire is a major threat to maintaining the protective values of woody vegetation on watersheds. The watershed conservation program should give high priority to fire suppression, which is a prime factor in good management.

The rewards to be reaped from better Brandywine forests are manifold. In addition to the economic values, they provide for more abundant wildlife and add a priceless beauty to local scenes.

TREE PLANTING. An analysis of the tree planting job conducted in the Chester County Soil Conservation District indicates that special problems will have to be solved in order to achieve, in a reasonable length of time, the proper quantity of tree planting needed. The problems are chiefly economic and are faced similarly



Strip cropping along with other conservation practices will reduce erosion in the watershed by 85%.



Approximately 33 miles of streambank need erosion control.

Tree planting will result in excellent plantations such as this one near Ludwig's Corner and will provide watershed protection.

There is increasing interest in the fastgrowing locust tree for its value as fence post material.

in other watersheds. Briefly stated--with labor short and operating costs high, farmers are not sufficiently interested to make the comparatively long-term investment called for by woodland management.

The woodland assistance now available does not appreciably alter the situation. The small number of trees provided through the soil conservation district without cost are not enough to take care of farm planning requirements. Many operators do not attempt to fill out their needs from State supplies at $6 per thousand, even though the figure represents only a part of the cost to the Commonwealth. Not many landowners have taken advantage of payments offered by the Agricultural Conservation Program of the U. S. Department of Agriculture for tree planting. The sentiment is often voiced by farmers that they do not have the resources, at the right time, to do the job. Again, the analysis indicates that all landowners were not fully "sold" on the cash and conservation values of woodland. This points to a need for a better understanding of the value of woodlands to the individual and to the watershed.

At any rate, there is little doubt that this phase of the Brandywine program should be studied. Greater help and incentive--possibly to the extent of providing tree-planting crews and equipment--need to be considered. Certainly, farmers need to know more about the "money-ability" of their woods. A small start in this direction has already been noted. There is increasing interest in the fast-growing locust tree, which readily converts to cash as fence post material. More information as to this enterprise and the income possibilities of Christmas tree plantations would be helpful.

BENEFITS TO THE LANDOWNER

Recommended land use adjustments would leave in crops only those lands that can be adequately protected from erosion. Partially off-setting this change is the recommended switch to cropping of high grade land not currently cultivated.

Because crop yields are generally higher on the better grade lands, average per acre yields would increase. In addition, yields would rise because conservation practices promote moisture retention and fertility. Altogether, land use adjustments and conservation practices would increase average crop yields approximately 25 percent.

Expansions in pasture acreage and improved management would more than double the grazing value.

Woodland production would be increased approximately two-thirds through protection from fire and grazing, by stand improvement and timber harvest cuttings

Practices such as strip cropping, diversions and terraces, and changes from open to close growing crops, would reduce the amount of sheet erosion. Benefits from reduction in sheet erosion are based on experimental studies which indicate that as erosion occurs, all other production factors remaining the same, crop yields decline. Trends in crop yields over a period of years indicate that in many areas yields have not declined; however, this may be due to changes in production methods such as increased fertilizer applications, new seeds and insecticides, longer crop rotations and better cultural practices. In the absence of erosion, the adoption of the above improvements would have resulted in still higher yields.

It is apparent that the benefit from a reduction in soil erosion may occur through maintaining yields, lowering production costs or maximizing the yield increases from possible improvement in production methods. On the other hand, experimental studies where conditions of crop production are controlled have indicated that average crop yields decline 5 percent with each inch of topsoil loss.

For an individual farm, where the program would be completely installed in a 3-year period, increased annual farm returns would be greater than increased annual costs at the end of 4 years. Total benefits would exceed the total costs by the end of 9 years.

For the watershed as a whole, in-

creased annual farm returns would be greater than annual costs at the end of 8 years. By the end of the 20th year, the total cumulative benefit would exceed the cumulative cost by $9,766,000, and the annual net gain would be approximately $1,224,000. The annual benefit would continue to increase because values derived from tree plantings and erosion prevention reach their maximum in later years.

SEDIMENTATION

The principal source of sediment carried by the Brandywine is the sheet and gully erosion from farm lands, especially from the clean-tilled and winter wheat crops. Of lesser importance is material eroded from stream and roadbanks.

A study by the U. S. Geological Survey indicates an annual sediment load in the Brandywine at Wilmington of 52,000 tons. This tonnage is equal to 135,800 cubic yards of shoal material as dredged from the channel of Brandywine and Christina Creeks below Wilmington, according to the Army Corps of Engineers. At 27 cents per cubic yard, the annual cost for removing sediment brought by the Brandywine is calculated at $36,700.

Annual costs for removing sediment from highways and associated structures are calculated at $4,000.

More than 30,000,000 gallons of creek water are processed daily to make it suitable for domestic and industrial uses. Sediment collection is a major phase of the treatment. Expenses rise in direct proportion to increased rates of sedimentation, requiring larger amounts of alum and soda ash (or equivalent) and more work removing the sediment from settling and collecting basins, and filter beds. Direct and indirect costs for processing the water may well reach five figures in an average year.

RESERVOIRS. Many diversion reservoirs along Brandywine Creek have filled with sediment in a relatively short time. Reservoirs packed solid with mud can be found at old mill dam locations throughout the drainage system. Recent surveys of the Coatesville Reservoir on Rock Run and the Icedale Reservoir on the upper West Branch indicate the present rates of sediment deposition and their effect on storage capacities.

The original capacity of the 35-year old reservoir at Coatesville has been reduced approximately 5% by sedimentation. This volume of sediment amounts to an accumulation of 53,000 tons.

The original capacity of the Icedale Reservoir has been reduced approximately 23%. This amounts to an accumulation of 34,000 tons of sediment.

It is believed that the two watersheds have somewhat similar sediment producing characteristics but the lesser volume of sediment measures at Icedale is due largely to the channel type reservoir, which allows a high percentage of the fine sediment to pass-over the spillway.

REDUCTION IN SEDIMENTATION DAMAGE. By retarding erosion in the entire Brandywine watershed, sediment deposits induced by the creek would be appreciably reduced. With the recommended program fully installed the average annual cost of dredging Wilmington harbor would be decreased by $24,300.

Various measures would also reduce the volume of sediment deposited on highways and lower the annual highway maintenance cost by $2,800.

The cost of treating water for domestic and industrial uses would be lowered. For example, water treatment costs for municipal supplies would be lessened by about $3,000 annually through sediment reduction.

Any significant reduction in the quantity of eroded sediments that now reach the Brandywine would mean a direct saving in costs of water purification. The saving would vary from year to year, depending on seasonal conditions, and would increase as the requirements for water grow.

Silt pollution discourages recreational uses of the streams and seriously limits all forms of aquatic life. When it occurs in combination with industrial and municipal pollution, silt greatly aggravates the water purification problem.

A carefully applied watershed protective program would reduce damages from sediment by as much as 70 percent.

Dredges remove 135,800 cubic yards annually from the channels of the Brandywine and Christina Creeks at Wilmington.

Sediment has completely filled many of the diversion dams along the Brandywine, such as the one at Cupola.

Two of the more recent floods on the Brandywine Creek and its tributaries occurred in November 1950 and August 1942. Under present conditions of flood plain use and 1950 prices, the monetary damage caused by these floods would be approximately $40,000 and $1,750,000 respectively. Large floods, such as the one in 1942, caused additional hardship through illness and mental distress. Community functions and the normal activities of nearly all persons in the area are interrupted for several days. These also represent losses and damages, however difficult to appraise.

An analysis of recorded streamflow measurements indicates how often floods of different magnitudes may be expected to occur. The amount of damage caused by floods of varying expectancy is shown graphically in Figure 1.

The average annual damage, based on all floods over a 100-year period, is $121,000. It may be observed from Figure 1 that the average annual damage from the frequent floods--those that are expected to occur 10 or more times during a 100-year period--is $29,000. Floods expected to occur fewer than 10 times in the same period may cause damages amounting to $92,000.

About 88 percent of the flood damage is borne by industrial establishments. The remainder is distributed among commercial, residential, transportation and agricultural properties. The damage estimates include loss of wages and loss of profit as well as damage to property.

More than 4,500 acres of agricultural land are affected by inundation. Fortunately, most of this land is used for permanent pasture and, therefore, the damage is minimized.

Of the $121,000 average annual flood damage, 7 percent occurs on the main stem of the Brandywine Creek, 81 percent on the West Branch, 8 percent on the East Branch, and 4 percent on smaller tributaries.

LAND TREATMENT. Some of the important flood control measures recognized by the Department of Agriculture are reforestation and the improvement of present woodlands; openland improvement, including retirement of steep cropland to pasture, and the improvement of pasture; and various conservation measures applicable to cropland. The installation of such measures and practices is beneficial from the economic and social standpoint.

From the standpoint of flood control, all land use changes are aimed toward the same goal--control of the raindrop--its diversion to useful purposes. The aim is thus to increase the rate and the amount of water entering the soil and reduce the amount running off over the surface. For any one square foot of soil the amounts of additional infiltrated water are small. But when conditions are improved over an entire watershed the reduction in storm runoff rates and the peak associated with them may be expected to make important reductions in flood damage. This flood control technique does not involve taking valuable land out of production. Rather it is merely a putting of every acre to its best use in accordance with its capability.

STREAM CHANNELS. In addition to many small, individual farm jobs totaling approximately 10,000 linear feet, the following specific flood alleviation improvements are recommended.

(1) Channel improvements consisting of approximately 6,000 cubic yards of excavation to increase the channel capacity of the East Branch above and below the first crossing of Route 322 near the Davey Paper Company plant in Downingtown. The increased channel capacity would decrease the frequency of flooding in the area.

(2) Improvements to the channel of the West Branch through the Lukens Steel Company plant at Coatesville. These improvements would consist of removing 3 low dams now used for low head impoundments, and some excavation to remove channel deposition. The improvements would increase the channel capacity in this reach and reduce flood stages. A new system of collecting water to replace the low head impoundments would need to be devised.

(3) The installation of a trash rack is recommended above the Lukens Steel Company buildings on Sucker Run, a tributary

of the West Branch. Sucker Run passes under several of the plant buildings in a closed conduit that is susceptible to plugging with debris. The trash rack would remove debris from the run upstream from the conduit entrance, eliminating the possibility of plugging and resulting flood damage.

DIKING. Sixteen hundred feet of dike along the main stem of the Brandywine Creek is recommended for flood protection of Lenape Park near Lenape.

RELIEF FROM FLOODS

When the recommended watershed treatment program is installed, if the 1942 flood were to reoccur, the damages in terms of present valley development and prices would be reduced from $1,750,000 to $1,384,000.

If the 1950 flood were to reoccur, the damage would be reduced from $40,000 to $19,640. The recommended program would have a relatively greater effect on the more frequent floods in contrast to the rarer floods.

Average annual damage in the watershed would be reduced from $121,000 to $50,100, providing an annual benefit of $70,900. For the major streams of the watershed, present and future average annual damages, and the expected annual benefits are as follows:

	Present Damage	Future Damage	Benefit
Brandywine Creek	$ 8,200	$ 5,300	$ 2,900
East Branch	10,200	5,000	5,200
West Branch	99,200	37,200	62,000
Minor Tributaries	3,400	2,600	800

At those points where channel improvements and diking are recommended, it is expected that complete protection from flood losses would be provided for all floods whose frequencies range from once a year, to once in 25 years. Under present conditions of flood plain use, it would be impractical to install flood control measures to further reduce losses from floods of rarer occurrence.

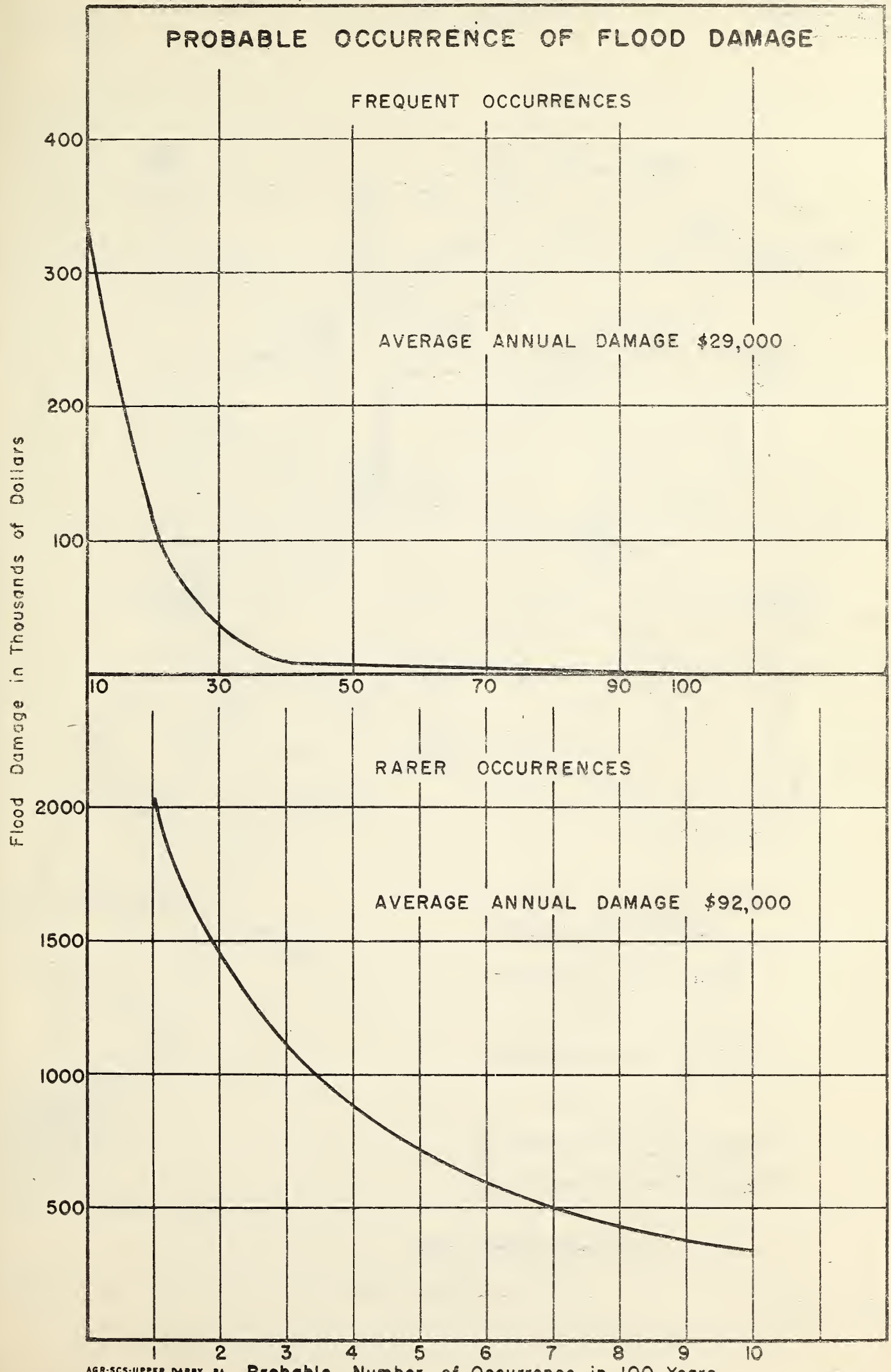
In general, greater reductions in losses from floods might be attained through changes in use of the land that is subject to inundation. The extent to which such adjustments might be economical, is obviously dependent upon the productiveness of the alternate uses.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ROBERT M. SALTER, CHIEF

BRANDYWINE CREEK
WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR

PROBABLE OCCURRENCE OF FLOOD DAMAGE



AGR-SCS-UPPER DARBY, PA. JANUARY 1952 Fig. 1

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ROBERT M. SALTER, CHIEF

BRANDYWINE CREEK WATERSHED

PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
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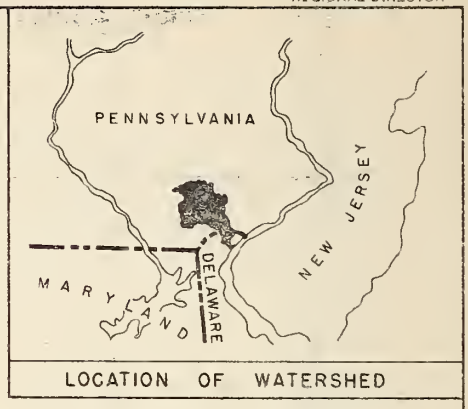

LOCATION OF WATERSHED

LOCATION MAP

Water Impoundments
and
Marsh Developments

LEGEND

Water Impoundments ②

Marsh Developments Ⓑ

SCALE OF MILES

Fig. 2

AGR-SCS-UPPER DARBY, PA.

JANUARY, 1952

The great dependence of municipalities and industry upon waters of the Brandywine drainage system has been underlined by a recent investigation. How vital is the need of securing a permanency for this water source can be seen in the data tabulated below:

Table 3. Source of Water for Industries and Municipalities 1/ Brandywine Creek Watershed

Source	Industry (gal./day)	Municipalities (gal./day)	Percent of Total Water Used
Streams	45,011,500	23,450,000	93.0
Wells	4,210,500	461,000	6.3
Springs	417,000	90,000	.7
TOTAL	49,639,000	24,001,000	100.0

1/ Table based on Brandywine Valley Association questionnaire of 1951 with 24 industries and 12 municipalities reporting.

In particular do the local farms require a steady and dependable source of water. Most of them have a limited means of water storage, but these are quickly depleted in droughty conditions. Stabilized springs and streams are a necessity. Wells are often uneconomical.

Insecure water supplies, it must also be noted, are detrimental to fire protection, health and such recreations as bathing and fishing.

INCREASE IN AVAILABLE WATER. The recommended watershed program aims at proper use of land and a maintained vegetative cover that would allow much of the water from rain and melting snow to enter the soil profile. Some of this water would be stored there to supply the needs of growing plants; the rest would be available to supply streams and reservoirs by underground flow and percolation.

Watershed conservation work would result in improvement for wildlife and associated human recreations. Forestry practices provide better wildlife habitat. Conifer planting provides much needed winter shelter. Woodland cutting on a selection basis results in an uneven-aged stand, desirable for wildlife.

Some 3,000 acres of upland odd areas including some on farms, may be best used for wildlife areas, about half of which need development. All need management. About 500 acres should be developed as aquatic habitat through water control structures.

There is great need for hedges and windbreaks. Most of the hedges should be multiflora rose living fences, for which there is a need of 290 miles. Windbreaks totalling 50 lineal miles are needed, mainly to protect buildings, roads and livestock.

All woodlands should have a shrub buffer zone about 20 feet wide along their edges. This aids the crop and grass growth and also protects the woodland while providing wildlife food and cover. Needs for borders of shrubs total 950 acres.

Species and quantities of shrubs needed in plantings to achieve the above practices, including streambanks, are:

Multiflora Rose	5,400,000 plants
Shrub Lespedezas	3,500,000 plants
Silky Dogwood	1,100,000 plants
Autumn Olive	1,200,000 plants
Tatarian Honeysuckle	1,300,000 plants
Other Species	1,400,000 plants
Total	13,900,000 plants

Farm ponds are growing in importance with the increasing use of water for many rural purposes. About 500 such ponds are needed in the watershed. They would contribute materially to wildlife habitat improvement. Many upland birds and mammals, as well as the truly aquatic species, make use of ponds and the tree and shrub plantings around them.

About 375 of the ponds would produce fish, mostly largemouth bass and bluegills. Under good management they can yield 29,000 pounds of hook and line fishing annually.

MARSH DEVELOPMENT. There are a number of opportunities to develop useful habitat for muskrats, waterfowl and fish in marshy places on the watershed. While such developments would be of definite recreational value to the hunter and fisherman, the potential income from muskrat furs is worth mentioning, even if it should serve only to provide "spending money" for the farm youngster. Again, such revenue is capable of reaching substantial proportions under careful "muskrat farm" management.

The largest areas for such development occur along Marsh Creek near the Pennsylvania Turnpike. Locations examined are shown in Figure 2. Data regarding the potentially important marshes are as follows:

Marsh	Location	Surface Area (acres)	Watershed Area (sq.mi.)	Watershed Area (acres)	Height of Dam (feet)
A	2.0 Miles N. West of Wagontown	8.53	.426	272.6	6.0
B	2.0 Miles N. West of Guthriesville	4.27	.11	70.4	5.8
C	.5 Mile N. East of Honeybrook	7.82	.26	166.4	5.0
D	1.5 Miles W. of E. Nantmeal	375.00	5.72	3660.0	8.0

Typical locations provide for a small basin of deep water next to the dike resulting from excavation for the fill. The balance of the flooded area would be shallow--generally not over 24" deep--and well suited for the growth of emergent aquatic plants.

WATER IMPOUNDMENTS. A notable lack of significant bodies of water in the Brandywine watershed constitutes a severe restriction for those who enjoy boating, bathing and fishing. This also denies other values relating to wildlife refuges and scenic appeal--as well as the more utilitarian possibilities of added fire protection, stock water and supplemental irri-

gation. Because an interest in creating additional bodies of water exists along the Brandywine, a survey of potential locations was made. (Figure 2) For future reference and consideration, 8 locations are detailed in the Appendix.

A great many farm ponds, such as this one at Marshallton, are needed for stock water, fire protection and recreation.

The development of swampy places in the watershed, including Marsh Creek, would improve habitat for muskrat, waterfowl and fish.

Good leadership work and financing are necessary to complete the watershed program. Cooperation is another vital factor--in fact, the key to success in a project of this sort. There has to be a common, unified desire to get the whole job done as quickly as possible, and to maintain the plan when it has been established. In reality, there is widespread public interest in what happens on the Brandywine. The type of effort made here may well serve as a model for thousands of other watersheds facing similar soil and water problems.

COSTS. The estimated cost of installing the total, recommended program is $4,383,116. Total annual maintenance costs for the program would be $799,529.

The land treatment phases would cost $4,111,316 to install and $793,859 yearly to maintain. Approximately 89 percent of this is for the establishment of approved measures and practices. The remaining 11 percent would be applied to technical services.

Additional measures would require $271,800, of which $200,300 would be allocated to stream channel improvement, $65,000 for streambank protection and $6,500 for diking. The annual maintenance cost for these measures would be $5,670--$4,390 for stream channels, $710 for streambanks and $570 for dikes.

FACILITIES. The watershed program would be planned and established as part of the programs of the Chester County Soil Conservation District in Pennsylvania and the New Castle County Soil Conservation District in Delaware. The governing bodies of these districts would furnish the leadership necessary in a program of this kind. It would be their duty to obtain and coordinate the services offered by many agencies and organizations in carrying out the educational, operational, and evaluation activities. The Supervisors would also determine priorities for work areas and guide the activities of all agencies in these areas. The following explains how some of the agencies and organizations can help in carrying out this program:

The Soil Conservation Service of the U. S. Department of Agriculture working primarily through the districts could furnish a wide range of technical assistance: farm planners, agronomists, soil scientists, engineers, biologists and hydrologists. The Soil Conservation Service would participate in all phases of the work.

State Agricultural Extension Services, through their activities and established programs, are especially equipped to aid in facilitating the educational aims of the watershed work plan.

Brandywine Valley Association, a highly active and effective organization of approximately 1,000 business and agricultural interests, has already attracted nation-wide attention in its informational efforts to conserve the watershed. The Association has the complete watershed program as its main goal and could be expected to furnish knowledgeable assistance in the informational and operational work.

The Production and Marketing Administration of the U. S. Department of Agriculture is set up to help with market adjustments to fully utilize the increase in dairy and beef products expected from the greater emphasis on grassland farming. Through its system of payments, it is in position to encourage the establishment of Agricultural Conservation Practices (ACP) to be integrated in a complete watershed treatment.

State Departments of Forestry are sources of operational assistance in woodland management areas. They are also sources of stock for new tree plantations.

State Fish and Game Commissions, as the authorities administering fish and wildlife management within the watershed, provide technical advice and assistance relating to stocking farm ponds and management of public fish and wildlife habitat relating to the watershed conservation program. In addition, they are currently making substantial contributions to the watershed public information program.

State Highway Department would be called upon for advice and assistance in problems of roadbank erosion, sedimentation on roads and related structures, and in

problems of highway drainage on farmlands.

Farmers Home Administration and Farm Credit Administration of the U. S. Department of Agriculture would participate in operations related to changes in farm enterprise, land tenure and supplementary financing as may be necessary to insure success for the watershed program.

Vocational Agriculture departments in schools could furnish invaluable help to the watershed program by relating some of the curricula to farm operations, conservation practices and concepts needed to preserve the Brandywine itself.

Public schools, farm, business and civic organizations could find no worthier common project than a studied effort to keep the watershed conservation program to the forefront in their educational and informational activities.

Sportmen's organizations, supported by thousands of Brandywine hunters and fishermen, have already proved a powerful aid in formulating a conservation program for the watershed. Their efforts in helping to extend the services of the Fish and Game Commissions and other agencies would find an even greater usefulness in coordination with the complete watershed treatment program.

The **Sanitary Water Board of Pennsylvania**, the **Water Pollution Control Commission of Delaware** and the **U. S. Public Health Service**, functioning cooperatively on the Brandywine, have already made great strides toward the elimination of water pollution from industrial wastes and municipal sewage. Their activities would continue to abet the over-all aims of the watershed treatment program.

U. S. Geological Survey is equipped to obtain information and maintain records of streamflow, suspended sediment and the chemical qualities of water. Largely through observation of test wells, the Survey also makes studies of potential groundwater supplies and variations in groundwater levels.

Academy of Natural Science, Philadelphia, maintains an interest in the environmental changes for flora and fauna as they may be brought about by the watershed treatment program. Studies made by this body would be an excellent means of checking on the success of the effort.

From the foregoing list, the far-reaching requirements of the watershed program can be easily grasped. It is not stretching the meaning of a phrase to say that saving the Brandywine for future generations yet unborn is "everybody's job."

INSTALLATION. Most of the work involved in the establishment of the land treatment program would be done by the farmers. Nearly all the equipment required to install the various practices and measures is available on every farm. Many of the measures, such as tile drainage, fencing, farm ponds, tree planting, land clearing, and obstruction removal, can be established during the season when work load is lightest.

The installation of additional measures would generally be the responsibility of the primary benefiters.

The channel improvement on the West Branch at Coatesville and the installation of a trash rack on Sucker Run would provide flood protection to and be the responsibility of the Lukens Steel Company. The channel improvement work above and below the highway bridge carrying Route 322 across the East Branch below Downingtown would be the responsibility of the Pennsylvania Highway Department. The diking recommended along the east bank of the Brandywine at Lenape Park would be the responsibility of the Park in return for flood protection.

TIMETABLE. Parts of the program have already been launched through the efforts of the two soil conservation districts, cooperating farmers, Federal, State and community agencies. Public information and education regarding the need for a watershed plan have had an excellent beginning aided by schools, banks, civic, farm and sportsmen's organizations. The bulk of the work, however, remains to be done. The entire program could be completed in 10 years.

THE WATERSHED'S NEW LOOK

The prospects for the new Brandywine community watershed, following a period of integrated soil and water conservation work, stimulate the imagination. And yet the conceivable improvements in both the tangible and intangible assets of the region can be predicted with a certainty based on scientific experiment and experience. The contrast between the anticipated Brandywine tomorrow, and other areas still in the problem stage, would be striking indeed.

Ribbons of contour strip cultivation would wind across the gentler slopes of farmland, the dark grasses and grains setting off the lighter bands of open-tilled crops. Land patterns would be ever-changing as farmers rotated their crops to keep the soils fertile, well watered and structurally sound. Where the rains once scarred steep slopes, sturdy, young trees would offer protection for the soil and shelter for wild creatures.

Across the slopes, diversion terraces would move the rain-water slowly off the land, giving the moisture ample time to infiltrate the soil. Hundreds of ponds would provide swimming and fishing. Man-made marshland preserves would encourage waterfowl. Out of well-kept farm woodlots, would arise the sounds of axes and saws at work, bespeaking of greater income for the valley in the selective cutting and marketing of timber from formerly idle or erosion-menaced acres.

Transformation would come to waters of the Brandywine network of streams...in the moderation of seasonal high and low levels...in reduced floods and flood damages...in the lessened frequency of bank overflows...in the rarer interruptions and inconveniences caused by rampaging torrents. The waters would be clearer, no longer clogged with sediment.

Residents of the watershed would take more pleasure in contemplating the harmonious soils and waters of their valley..in reckoning its significance in a release from burdensome expenses to themselves and their communities formerly wrought by water pollution, by flood injuries to roads and the agricultural and industrial economy upon which his existence depends. And the schoolchild would be afforded a first-hand view of man and nature working together.

LAND TREATMENT, CONVERSION AND MEASURES

Specifically, soil and water problems could be solved or abated by--(1) land treatment measures and practices; (2) land use conversions; and (3) additional measures of a structural nature. The greatest change would occur on farmlands as they make the transitions to a more permanently productive agriculture. However, alterations in use and treatment of town and city areas would be no less important to the fulfilment of the entire conservation project.

In developing the recommendations that are tabulated at the end of this section, it was found expedient to approach the watershed program through 8 problem areas, each having similar soils, topography, farm operations and ownership. For the sake of convenience, data on the areas have been included in the Appendix. Finally, the itemized recommendations affecting agriculture were projected from on-site conservation studies of over 300 local farms.

Land treatment practices and measures, plus installation and maintenance costs, are shown in Table 4. The scope of land use conversions may be studied in Table 5. Treatments and measures are calculated to raise or maintain the soil's productiveness--to prevent erosion and stabilize water resources. Conversions would put each acre to its best potential use and involves reductions in acres of cropland and idle acreage, with attendant increases in perennial hay, pasture, woodland and wildlife areas.

Each of the scores of specialized tasks would be coordinated to provide the Brandywine community watershed a successful and unified treatment program.

Table 4. INSTALLATION AND MAINTENANCE COSTS
RECOMMENDED LAND TREATMENT PRACTICES AND MEASURES
BRANDYWINE CREEK WATERSHED

Practice	Unit	Quantity	Installation		Annual Maintenance	
			Unit Cost (dollars)	Tot. Cost (dollars)	Unit Cost (dollars)	Tot. Cost (dollars)
CROPLAND TREATMENT						
Contour Farming	Acres	2,900	.55	1,595	.13	377
Crop Rotation	Acres	48,500	.40	19,400	-	-
Cover Cropping	Acres	12,000	4.75	57,000	1.50	18,000
Crop Residue Management	Acres	29,500	.25	7,375	-	-
Contour Strip Cropping	Acres	54,900	1.75	96,075	.02	1,098
Diversions & Terraces	Miles	92	378.00	34,776	4.00	368
Outlets & Farm Watercourses	Acres	510	269.50	137,445	13.50	6,885
Establishing Perennial Hay	Acres	12,400	42.75	530,100	17.40	215,760
PASTURELAND TREATMENT						
Pasture Improvement	Acres	13,100	32.50	425,750	13.85	181,435
Establishing Pasture	Acres	13,200	40.00	528,000	15.70	207,240
Fencing	Rods	137,000	2.40	328,800	.20	27,400
Pasture Management	Acres	42,800	2.00	85,600	1.75	74,900
Contour Furrows	Acres	660	18.00	11,880	3.30	2,178
WOODLAND TREATMENT						
Woodland Grazing Protection	Acres	4,400	2.65	11,660	.20	880
Woodland Fire Protection	Acres	54,300	-	-	.01	543
Woodland Improvement	Acres	44,100	4.40	194,040	.17	7,497
Woodland Harvest Cutting	Acres	5,300	32.75	173,575	6.00	31,800
Tree Planting	Acres	6,050	27.75	167,887	-	-
WILDLIFE						
Wildlife Area Improvement	Acres	3,000	43.00	129,000	1.65	4,950
Borders	Acres	950	45.50	43,225	3.30	3,135
Hedges	Miles	290	125.00	36,250	1.65	478
Fish Pond Management	Acres	220	17.65	3,883	17.65	3,883
DRAINAGE						
Open Drains	Miles	80	1,690.00	135,200	7.90	632
Covered Drains	L. Ft.	244,000	.45	109,800	.01	2,440
MISCELLANEOUS MEASURES						
Farm Ponds	No.	500	700.00	350,000	3.30	1,650
Clearing & Obstruction Removal	Acres	5,600	85.00	476,000	-	-
Windbreak Planting	Miles	50	90.00	4,500	6.60	330
Channel Improvement	L. Ft.	10,000	1.25	12,500	-	-
				4,111,316		793,859

Table 5. LAND USE CONVERSIONS
BRANDYWINE CREEK WATERSHED

Land Use	Present (acres)	Recommended Future					
		Cropland (acres)	Perennial Hay (acres)	Pasture (acres)	Woodland (acres)	Wildlife (acres)	Miscellaneous (acres)
FARMLAND							
Cropland	72,241	51,689	10,226	7,100	1,834	231	1,161
Pasture	36,154	710	1,280	31,553	1,585	148	878
Woodland	19,550	90	148	662	18,168	262	220
Miscellaneous	23,969	1,590	1,684	5,422	4,846	2,238	8,189
Total Farmland	151,914	54,079	13,338	44,737	26,433	2,879	10,448
		-18,162	+13,338	+8,583	+6,883	+2,879	-13,521
NON-FARMLAND							
Woodland	25,675	-	-	-	25,675	-	-
Miscellaneous	19,401	-	-	-	2,226	2,881	14,294
Urban, Highways, Streams, Impervious	14,210	-	-	-	-	-	-
Total Non-Farmland	59,286	-	-	-	27,901	2,881	14,294
TOTAL WATERSHED	211,200	54,079	13,338	44,737	54,334	5,760	24,742
Net Changes		-18,162	+13,338	+8,583	+9,109	+5,760	-18,628

TELLING THE PUBLIC

No more conducive atmosphere for an effective Brandywine watershed program can be attained than through a planned campaign to inform the public on the aims, ideals and plan of operations. In fact, the program will falter without continuing sound public information and education activities.

So important is this phase of the program that the selection of a committee, or similar organization, especially charged with the responsibility, might well be considered. Their assignment would be to keep a "moving picture" in the public eye as to what is being done on the Brandywine--where and why it's being done, and who is doing it.

INFORMATION STAFF. Whether or not a special committee is set up, component parts of the information effort should be assigned to individuals connected with the Brandywine program. It is recommended that the administration be delegated to a carefully chosen group made up of a director and persons qualified to work closely with newspapers, general publications, radio and television, schools and affiliated organizations, farmers and farm organizations; industry and industrial organizations, fraternal, sportsmen's and civic organizations; and visual aid specialists, i.e., photographers, artists, sign-painters, etc.

DIRECTOR OF INFORMATION. Duties of the director would be (a) to establish a good liaison with the operational phases of the program; (b) to coordinate assignments for the information personnel; (c) to supervise preparation of material; (d) to keep the information program in good balance and taste; (e) to see that all public information media receive fair and equal availability to Brandywine information; (f) to set up an information timetable for releases and changes of emphasis in material; (g) to prevent misinformation or misconstructions related to the Brandywine watershed program; and (h) call meetings and make other working arrangements for the information staff.

NEWSPAPERS. The whole-hearted support and understanding of the Brandywine press would be a vital facility for the entire program. Therefore, the person charged with this field should have, or work toward, a friendly relationship with local newspapers. He or she should know enough about press problems to have a proper regard for deadlines, taboos, and interests of individual editors and their readers. Newspaper material should be truly "newsy" as against "hand-outs" and "canned" releases. Newspapers, daily or weekly, large or small, should be given equal opportunity to be "first with the news".

PUBLICATIONS. As magazines, farm, trade and other specialized publications will have their own peculiar interests in the Brandywine program, it is suggested that an individual with this type of knowledge be included in the staff. Such a person should have the ability to write or inspire articles of a specialized nature. From time to time, it may facilitate the program, to prepare and publish booklets and fact sheets. General knowledge of publishing matters--printing, engraving, distribution and costs--would be of definite value in the hands of one of the information staff members.

RADIO AND TELEVISION. Actual broadcasting and televising would probably be a minor portion of the information work. Nevertheless these media should be carefully integrated with the program. News releases and related data should be given to the radio and television stations in the same manner as the press and other publishers. Other relationships should be on a like, friendly basis. In this manner, the broadcasters will also be given the opportunity to arrange for special event coverages and presentations of significant developments in the watershed.

SCHOOLS. Enthusiasm for the watershed treatment program among Brandywine youth would, in many cases, help to arouse a like attitude among adults. There is ample op-

portunity for schools to participate in the greater community effort, in any case. For that reason, a special relationship with schools is to be desired. The person charged with this should insure that schools and affiliated organizations are supplied with study materials, visual aids and programs especially designed to engage the interest of the young people, their teachers and advisers. The materials should be definitely arranged to keep Brandywine information at a high level with all age groups.

FARMS. It is obvious that farmers owning most of the Valley lands must be a paramount consideration in the watershed information program as well as the operational phases. A person closely associated with Brandywine agriculture should oversee this phase--and insure that it is kept in proper perspective. News stories, special articles and publications related to the watershed program should stress the importance of farmer cooperation and conservation work progress on the individual farms in both the soil conservation districts involved. Materials and programs should be made available to all local farmer organizations.

INDUSTRY. Probably no other group has a keener interest or greater stake in the flood alleviation and water purification results of the Brandywine watershed treatment program than has local industry. It should be noted that this group includes not only the factory owners, themselves, but also the thousands who work in factories and depend upon them for bread and butter. The voice of industry should certainly be heard in the information effort and careful administration should be directed toward industry's working part in the common cause.

OTHER ORGANIZATIONS. Specially developed exhibits, materials and programs should be offered to all specialized and general organizations functioning locally. The effort would add strength and support to make the watershed improvement program a true community venture. Sportsmen's organizations will be drawn by the wildlife aspects of the work. Bankers' groups will be interested in the economic significance. Civic and fraternal groups may want more general or popular information. Someone on the staff should see that all such interests are satisfied appropriately. These activities would be repaid with a more facile and enthusiastic operational Brandywine program.

VISUAL AIDS. It is recommended that at least one information worker be especially charged with responsibility for securing and maintaining an effective file of visual material. This is emphasized because experience has indicated this facet to be one of the most potential sources of weakness of information programs in general. A studied attempt should be made to collect good photographs that are genuinely useful for the press and other publications. Additional aims for the visual specialist might be--graphic exhibits for public display, color slides, movies, special material for television, illustrated maps, signs and posters.

Sources for information assistance are suggested in another section of this report that outlines functions of various agencies and groups participating in the program. The ability and imagination thus assembled would determine the course, form and efficacy of Brandywine information. The designees would undoubtedly explore and give attention to all the well-known avenues of public relations. Perhaps a primary information service to the public would be to make it very clear as to just where information on the Brandywine program may be secured--by letter of inquiry, by telephone and by personal visit.

Ultimately, the information work should be directed at three major goals: maintaining the public interest, keeping the public factually informed, and spurring public activity--in furthering the treatment of the Brandywine community watershed. All information material should be measured by these standards.

TECHNICAL APPENDIX

COMMUNITY WATERSHED

SOIL AND WATER CONSERVATION WORK PLAN

FOR

BRANDYWINE CREEK

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SECTION I - PHYSICAL FACTORS

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Runoff rates in the watershed vary greatly, but under conditions experienced several times in recent years, are destructively high--as much as 90 percent of the rainfall.

The total annual streamflow at Chadds Ford, Pennsylvania, when measured in inches of runoff from the watershed above that point, averages 17.82 inches with a range in the 39 years of record from 10.44 to 29.95 inches. The annual amounts reflect not only the rainfall of dry and wet years, but the influence of various watershed conditions on the rainfall. The same amount of rainfall may produce a serious flood or no appreciable flood under different watershed conditions.

Brandywine Creek Watershed has a moderate East Coast climate of relatively mild winters, and summers that are warm and frequently humid. Temperatures rarely reach 100° F. but 90° F. is recorded on 15 days of an average summer. Less than 100 days in a normal winter have temperatures below freezing. Below zero temperatures are infrequent.

The average growing season varies from 180 to 200 days, from April 15 to 22, average date of the last killing frost, to October 7-20, the first in fall.

Precipitation is distributed rather evenly throughout the year to produce an average total of about 45 inches, of which approximately 3 inches is the melted equivalent of snow. Normal warm season (April to September inclusive) precipitation is approximately 25 inches.

The temperature and precipitation averages by months for 3 stations in the watershed with long climatological records are given in Table 1.

Table 1. Temperature and Precipitation Averages by Months
Brandywine Creek Watershed

Wilmington, (Porter Reservoir) Delaware - Lat. 39° 46' - Long. 75° 31' - Elev. 260'

Month	Temperature °F (39-Year Record)	Precipitation (39-Year Record)
January	32.7	3.54"
February	32.6	2.97
March	42.3	3.78
April	52.1	3.82
May	63.0	3.78
June	71.3	4.05
July	76.0	4.79
August	74.0	5.10
September	68.1	3.62
October	56.8	2.98
November	45.7	3.19
December	35.0	3.30
YEAR	54.1	44.92

Table 1. (Cont'd.) Temperatures and Precipitation Averages by Months
Brandywine Creek Watershed

West Chester, Pa. - Lat. 39° 57' - Long. 75° 36' - Elev. 440'

Month	Temperature °F (94-Year Record)	Precipitation (99-Year Record)
January	30.6	3.78"
February	31.3	3.68
March	39.3	3.95
April	50.0	3.76
May	61.0	4.25
June	69.7	4.25
July	74.4	4.77
August	72.2	4.73
September	65.7	3.86
October	54.6	3.62
November	43.3	3.54
December	33.3	3.79
YEAR	52.1	47.98

Coatesville, Pa. - Lat. 39° 58' - Long. 75° 50' - Elev. 342'

Month	Temperature °F (62-Year Record)	Precipitation (62-Year Record)
January	30.2	3.87"
February	30.6	3.62
March	39.9	4.13
April	50.5	3.73
May	61.5	3.90
June	70.4	4.21
July	74.9	4.66
August	72.8	4.58
September	66.3	4.58
October	54.2	3.43
November	43.0	3.24
December	32.8	3.76
YEAR	52.3	47.71

Because of differences in soil, topography and general agricultural conditions the pertinent land data have been assembled by problem areas, of which 8 are designated in Figure 1. Brief descriptions of the soils and other land conditions in the various problem areas follow.

Problem Area 1 (Welsh Mountain, Barren Ridge and North Valley Hills) The areas are steep, frequently stony and of relatively small agricultural value except for woodland. Considerable real estate development has occurred north of Downingtown, Coatesville and Parkesburg in the North Valley Hills.

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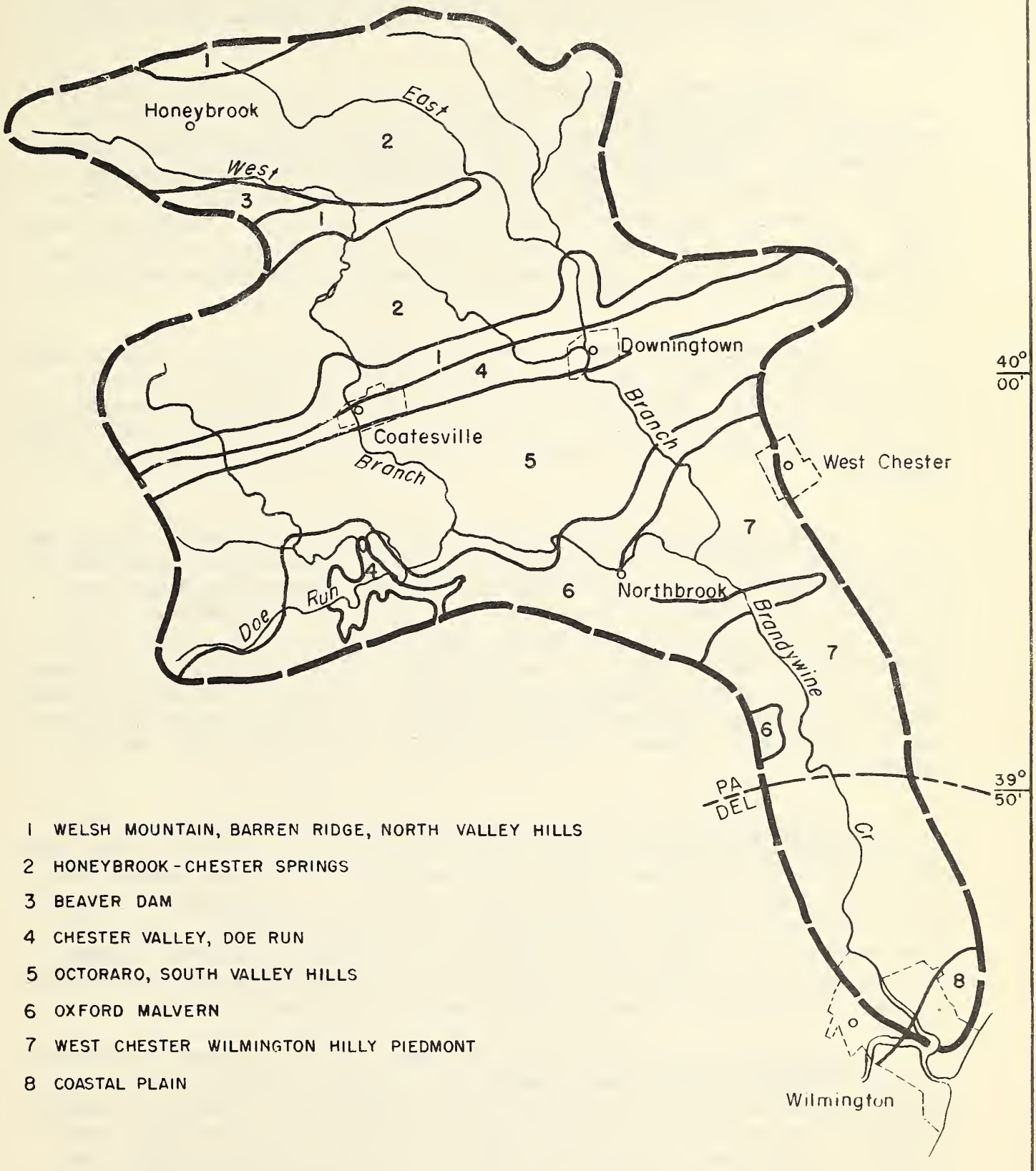
ROBERT M SALTER, CHIEF

PROBLEM AREA MAP OF THE BRANDYWINE CR WATERSHED

PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L PATRICK
REGIONAL DIRECTOR



76° 00' REFERENCE PA & DEL TRANSPORTATION MAP

L-1256

75° 30'

AGR-SCS UPPER DARBY PA

JANUARY 1957

Fig. 1

The soils are shallow to moderately deep, medium textured, with low natural fertility and low to fairly high amounts of water available for plant use. Drainage is good to excessive, permeability good to rapid. Approximately one-third of the soils are stony and unsuited to agriculture.

Problem Area 2 (Honeybrook and Chester Springs) The area is rolling to hilly and makes up a large part of the farm land in the watershed. The majority of the soils are fairly deep with good natural fertility. They are capable of holding an adequate amount of moisture for plant needs and are good agricultural soils. Soil textures are medium and permeability is moderately high. There are many small areas of poorly drained soils that in the aggregate make up 15 percent of the problem area. General farming predominates with some specialization in the growing of tobacco and tomatoes.

Problem Area 3 (Beaver Dam) The area is rolling to hilly. Most of the soils are deep, medium textured, and have plenty of moisture for plant growth. Fertility ranges from fair to high and permeability is good. Seventeen percent of the soils are poorly drained and 21 percent only moderately well drained. General farming and dairying predominate.

Problem Area 4 (Chester Valley and Doe Run) Chester Valley includes 9,942 acres in the watershed, of which Downingtown, Coatesville and other towns occupy considerable portions. Dairy farms are the principal agricultural enterprise. The Doe Run area includes 1,670 acres, most of which is used for fattening beef cattle. Some of the better agricultural soils of the watershed are located in these areas. They are deep, medium textured and fertile. About 75 percent are well drained and transmit water and air easily. Available water for plant use is plentiful. These areas are largely in the Limestone Valley Province.

Problem Area 5 (Octoraro and South Valley Hills) Steep hills with shallow soils on the slopes and moderately deep soils on the tops and in the valleys characterize this section. Soils are medium textured, fertile and have low to adequate amounts of moisture for plant use. Drainage is good, permeability a little too rapid. The soils have been and are intensively cropped. Dairying and general farming are the major land use. The soils are highly erodible and more gullying has occurred here than in other parts of the watershed.

Problem Area 6 (Oxford and Malvern) This is known as an area of good farms on a relatively gentle topography. Fairly deep soils with adequate moisture for plant growth predominate. They are medium textured, transmit water and air easily, and have good to high fertility. Only about 7 percent of them are poorly drained and 10 percent moderately well drained. The farms are largely dairy with some general farming and some specialization in truck crops and flower growing.

Problem Area 7(West Chester and Wilmington Hilly Piedmont) The entire area is hilly. Adjacent to the Brandywine, slopes are steep, and are largely in pasture or woods belonging to estates. Most of the soils are medium textured, well drained, permeable, and fairly fertile. There is ordinarily plenty of moisture available for plant use. Dairying predominates.

Problem Area 8 (Coastal Plain) All of the area occurring in the Brandywine Watershed is within the boundaries of the city of Wilmington and consequently is not important insofar as soils are concerned.

Table 2. Acreage of Soils According to Parent Material by Problem Areas, for Land in Farms Brandywine Creek Watershed

Problem Areas 1/ -	Pennsylvania 1	2	3	4	5	6	7	Delaware 7	Watershed Total
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Upland Soils									
Derived From: Gneiss, Schist, Granite	2,749	40,944	565	245	20,243	26,348	18,564	4,835	114,493
Limestone, Calcareous Shale	-	1,300	134	7,519	88	57	24	-	9,122
Sandstone, Quartzite	5,924	2,100	106	-	-	169	96	502	8,897
Basic Igneous Rock	-	900	620	-	-	113	167	100	1,900
Slate, Shale, Serpentine	-	3,450	174	-	-	198	3,229	2,442	9,493
Alluvial Soils									
Mostly From: Gneiss, Schist, Granite, Shale	-	1,300	162	1,328	1,507	1,385	1,842	485	8,009
TOTAL	8,673	49,994	1,761	9,092	21,838	28,270	23,922	8,364	151,914

1/ See problem area map.

Table 3. Present Land Use by Problem Areas
Brandywine Creek Watershed

Problem Area	Farmland					Non-Farmland			
	Total	Crop	Pasture	Woodland	Miscel-laneous	Total	Woodland	Miscel-laneous	Highways Roads, etc.
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Welsh Mt., Barren Ridge and North Valley Hills	8,673	4,477	1,374	1,194	1,628	5,745	4,357	523	863
Honeybrook, Chester Springs	49,994	25,869	10,011	7,532	6,582	21,820	10,573	6,938	4,309
Beaver Dam	1,761	1,141	356	105	159	839	547	162	130
Chester Valley and Doe Run	9,092	4,093	2,401	1,438	1,160	2,520	531	1,083	906
Octoraro and South Valley Hills	28,270	14,701	5,503	3,381	4,685	11,688	4,792	4,496	2,400
Oxford-Malvern	21,838	8,626	7,469	3,123	2,620	5,278	1,202	2,426	1,650
West Chester Wilmington Hilly Piedmont	32,286	13,334	9,040	2,777	7,135	10,901	3,673	3,773	3,455
Coastal Plain	-	-	-	-	-	495	-	-	495
TOTAL	151,914	72,241	36,154	19,550	23,969	59,286	25,675	19,401	14,210

Table 4.
Present and Future Land Use by Soil Depth and Drainage
Brandywine Creek Watershed

Land Use	Deep, Well Drained		Shallow, Well Drained		Imperfectly and Poorly Drained		Total	
	Present	Future	Present	Future	Present	Future	Present	Future
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	50,911	56,047	13,821	9,434	7,509	1,936	72,241	67,417
Pasture Land	16,338	19,887	4,820	4,953	14,996	19,897	36,154	44,737
Woodland	22,671	22,900	12,652	21,402	9,902	15,792	45,225	60,094
Miscellaneous	19,756	10,842	9,917	5,421	13,697	8,479	43,370	24,742
Highways, Roads, Streams, etc.	-	-	-	-	-	-	14,210	14,210 1/
Total	109,676	109,676	41,210	41,210	46,104	46,104		
TOTAL WATERSHED							211,200	211,200

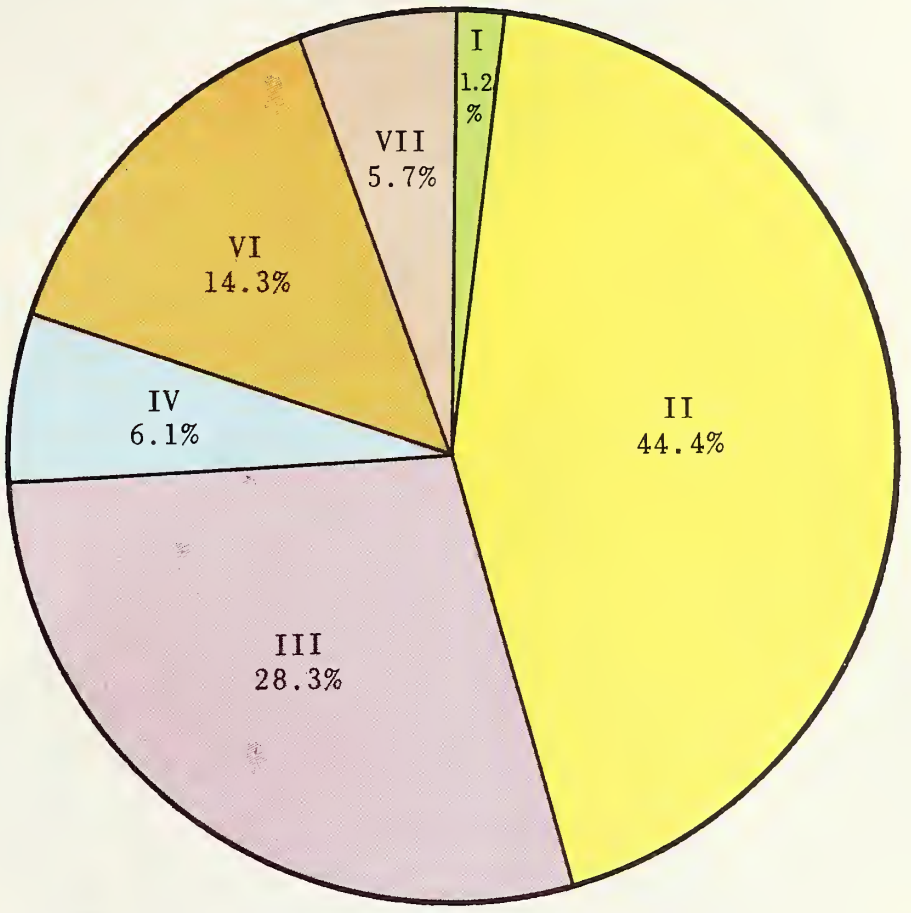
1/ Not divided.

Table 5. Land Use of Land in Farms, by Land Use Capability Classes 1/
Brandywine Creek Watershed

Land Use	I	II	III	IV	VI	VII
			PRESENT			
Cropland	1,097	40,626	23,323	2,592	3,078	1,525
Pasture	545	14,382	8,887	2,208	7,798	2,334
Woodland	55	4,958	4,871	2,865	4,709	2,092
Miscellaneous	110	7,497	5,984	1,628	6,064	2,686
TOTAL	1,807	67,463	43,065	9,293	21,649	8,637
			FUTURE			
Cropland	1,466	42,647	22,262	1,042	-	-
Pasture	280	17,848	11,558	4,420	9,175	1,456
Woodland	48	4,943	8,740	2,203	8,327	5,051
Miscellaneous	13	2,025	505	1,628	4,147	2,130
TOTAL	1,807	67,463	43,065	9,293	21,649	8,637

1/ For definition of classes see Figure 2.

LAND CAPABILITY CLASSES



MAJOR LAND USE ADAPTATION	LAND CAPABILITY CLASS	DEFINITIONS AND LIMITATIONS
SUITABLE FOR CULTIVATION	I	Very good land for cultivation. Nearly level and productive; not subject to erosion. Needs only ordinary good farming methods.
	II	Good land for cultivation. Mostly gently sloping, only moderately erodible. Some rather wet. Can be farmed safely with easily applied conservation practices.
	III	Moderately good land for cultivation. Mostly moderately sloping. Some too wet or too dry. Can be farmed safely with practical conservation measures, carefully applied and usually in combination of two or more measures. Mostly subject to water erosion in humid areas, and much of it to wind erosion in the Great Plains.
	IV	Fairly good land suitable for occasional cultivation. Generally strongly sloping; often shallow or very sandy.
NOT SUITABLE FOR CULTIVATION	VI	Land well suited for grazing or forestry: Steeply sloping, stony or shallow soil; some droughty. Requires careful management.
	VII	Land fairly well suited for grazing or forestry. Various difficulties encountered in its use, such as steepness of slope, shallowness or looseness of soil, droughtiness and salinity. Requires very careful management.

Fig. 2

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BRANDYWINE CREEK
WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR

LAND USE CAPABILITY MAP
OF
A BRANDYWINE VALLEY FARM

Fig. 3

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LAND AND WATER ECONOMY

Land

The number of farms in the watershed is calculated to be 1,445. They occupy an area of 151,914 acres, making the average farm 105 acres. As one approaches the population centers of Philadelphia and Wilmington, the size of individual holdings usually decreases.

There are dairy cows on approximately 60 percent of the farms and cattle on an additional 9 percent. Most of the additional cattle are beef types, there being a marked increase in pasturing this type of animal. Eighty percent of the farms indicated land used for pasture in 1944. Some form of livestock enterprise appears to be the main business on the majority of farms. Corn was grown on 72 percent of the farms; nine-tenths of these farms grew corn for grain. Barley and wheat are the important winter grain crops.

A number of properties are estate-type farms. Some are used for recreation, such as fox hunting, while others combine agriculture with recreation. Approximately 6 percent of all farms are operated by managers, while 10 percent are operated by tenants under a variety of rental bases. Slightly over 70 percent of all farms are owner-operated.

Farm tenancy has decreased in recent years from 16.7 percent in 1940 to 10.1 percent in 1945. The proportion of cash tenancy is considered quite high, due to the large number of properties owned by men living in the cities. Many of these properties are primarily residences, with the tenants working in nearby industrial plants. In many such cases little or no farming is carried on, unless the land is operated on shares by neighboring farmers.

Dairy cows constitute the largest single group of livestock. In 1944 there were approximately 16,000 cows and heifers over 2 years old in the watershed. In 1946 this number was reduced by at least 1,000 head, according to records kept by the Federal-State Crop Reporting Service in Harrisburg, Pennsylvania. Other cattle and calves bring the total cattle population to about 25,000. In addition, there are some 6,300 hogs of all types (about 10 percent of this number are kept for breeding purposes), about 188,000 chickens over 4 months old, and 2,300 horses, mules and colts. The fattening of beef cattle on pasture is rapidly increasing.

Fluid milk and ice cream are the principal products of the dairy industry. Poultry and eggs marketed within 50 miles constitute a large volume of business. Marketing of hogs and beef cattle is mostly through livestock centers, such as Philadelphia, Lancaster, Harrisburg and Baltimore. Many horses in the lower watershed are maintained for riding purposes.

Table 6. Crop Production in the Watershed 1/
Brandywine Creek Watershed

Crops	Acres 1/	10-Year Average Yields 2/	Total Production
		(bu.)	(bu.)
Clean Tilled Crops			
Corn	19,457	45.2	879,456
Potatoes	1,016	133	135,128
Others (mostly clean tilled, i.e., tomatoes, tobacco, peas, vegetables, soybeans for green feed).	10,445		
Grain			
Oats	5,418	34.2	195,296
Barley	3,251	34.9	113,460
Wheat	11,053	19.3	213,323
Soybeans	578	-	-
Other (rye, etc.)	534	-	-
Hay	20,489	1.51 (tons)	30,938 (tons)

1/ 1945 Agricultural Census.

2/ Acre yields are for Chester County, Pennsylvania and were furnished by the Federal-State Crop Reporting Service.

There are nearly 60,000 acres of land not in farms in the watershed. At least 40 percent of this area is in woodland, while nearly 25 percent is classed as urban, highways, railroads, streams and water surfaces. The remainder of the non-agricultural land consists of parks, cemeteries, golf courses and land held for real estate development. Nearly all of it is considered as openland; here and there tracts are reverting to brush and woodland through non-use.

The woodland area covers approximately 45,225 acres or 21.4 percent of the total Brandywine Watershed. The wooded acreage comprises forest and woodlots of varying sizes. About 12 percent is in tracts of 50 acres and over; 7 percent in tracts of 10 to 50 acres, and 3 percent under 10 acres. Less than half of the wooded acreage is in farm woodlots.

Water

A questionnaire was sent in 1951 by the Brandywine Valley Association to municipal, domestic and industrial water users in the watershed. The following tables indicate the amounts of water and treatment presently being used and the estimated needs for domestic purposes in 1960.

Table 7. Domestic Water Requirements 1/
Brandywine Creek Watershed

Present Population	188,000
Present Consumption (G.P.D.)	24,001,000
Estimated Population 1960	204,000
Estimated Consumption 1960 (G.P.D.)	26,112,000

1/ Twelve municipalities reporting - Brandywine Valley Questionnaire 1951.

Table 8. Industrial Use of Water 1/
Brandywine Creek Watershed

Use	Gallons Per Day	Percent
Cooling	20,482,437	41.3
Processing	18,933,472	38.1
Boiler Feed	2,005,455	4.0
Sanitary and Service	6,062,507	12.2
Other	2,155,186	4.4
TOTAL	49,639,057	100.0

1/ Twenty-four industries reporting - Brandywine Valley Questionnaire 1951.

Table 9. Method of Water Treatment 1/
Brandywine Creek Watershed

	Settling or Sedimentation	Softening	Complete Demineralization
Number of Industries	11	7	2

1/ Twenty industries reporting - Brandywine Valley Questionnaire 1951.

Table 10. Method of Municipal Water Treatment 1/
Brandywine Creek Watershed

	Chlorination	Filtration	Settling or Sedimentation
Number of Municipalities	7	5	4

1/ Twelve municipalities reporting - Brandywine Valley Questionnaire 1951.

Table 11. Estimated Per Capita Water Consumption
Brandywine Creek Watershed

Year	Per Capita Consumption
	(g.p.d.)
1920	77
1930	102
1940	115
1950	128 1/
1960	128
1970	128
1980	128

1/ From Brandywine Valley Questionnaire 1951.

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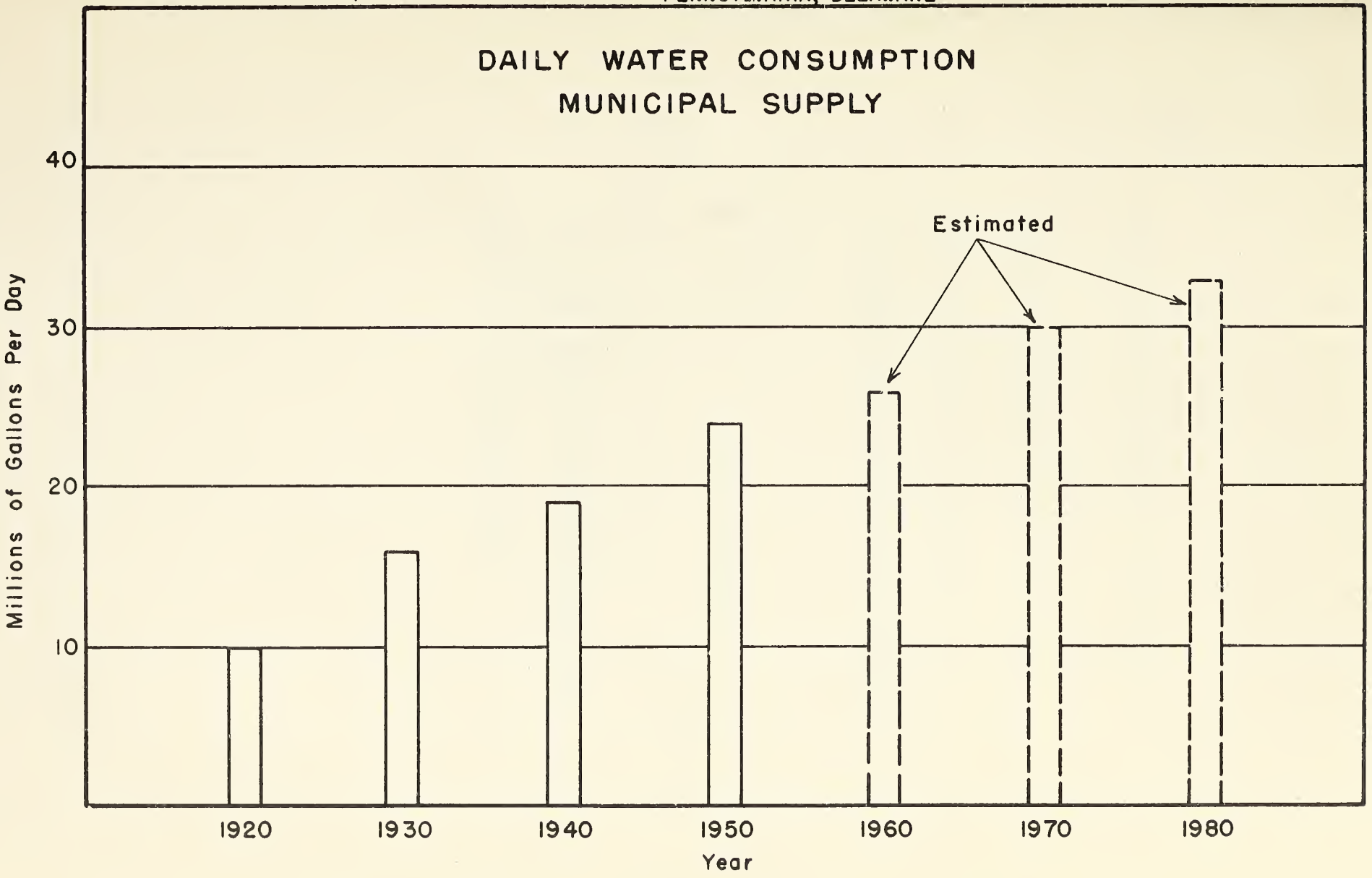
BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR



Based on Brandywine Valley Questionnaire

Fig. 4

AGR-SCS-UPPER DARBY PA

JANUARY 1952

SECTION III - HYDROLOGY

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An analysis of recorded streamflow measurements indicates how often floods of different magnitudes may be expected to occur. The historical record and sample calculations are shown in Table 12, while the peak discharge-frequency relationship is shown in Figure 5. A generalized peak discharge-frequency-drainage area relationship was drawn for the Brandywine Watershed from historical data within and outside of the watershed. (Figure 6).

To determine quantitatively the reduction in peak discharge assignable to land use changes it was first necessary to learn the present soil-cover conditions on the watershed as shown in the upper half of Table 13. A study was then made of experienced floods relating the rainfall that caused the flood to the amount and rate of runoff as measured in streamflow at the flow measurement stations maintained in the watershed. By assigning to each soil-cover complex a rate at which water enters the soil, a balance was struck so that the summation of runoff from all soil-cover groups was equal to the runoff measured at the streamflow station for the area under consideration.

To determine what runoff might be expected under future watershed conditions it was necessary to know the amount and distribution of soil-cover groups that would then prevail. (Table 13, lower half). By applying the same rates of water take-up that were found to balance the presently observed runoff, to the areas expected to prevail in the future, and making allowance for the detention effects of increased humus and of certain contouring practices, a reasonable value for runoff under the improved conditions expected to prevail in the future was obtained. A sample storm calculation and a summary of storm analysis are shown in Tables 14, 15, and 16.

Comparing the future value with the present, the reduction in peak flow is obtained. This reduction is not the same for all storms or for all areas within the watershed. It is greater on the smaller watersheds and for the smaller storms.

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BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

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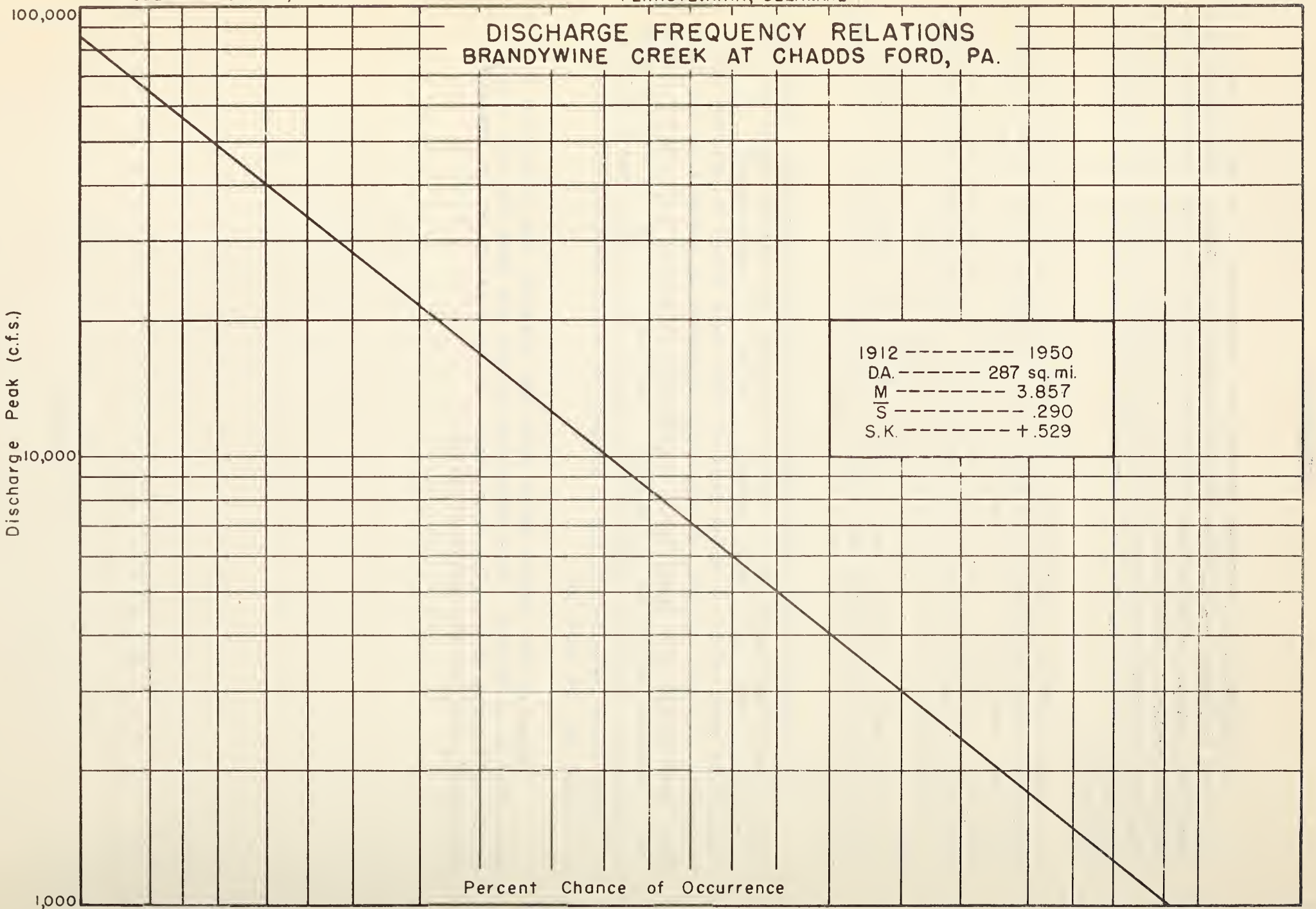

AGR-SCS-UPPER DARBY, PA. JANUARY 1952

Fig. 5

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BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

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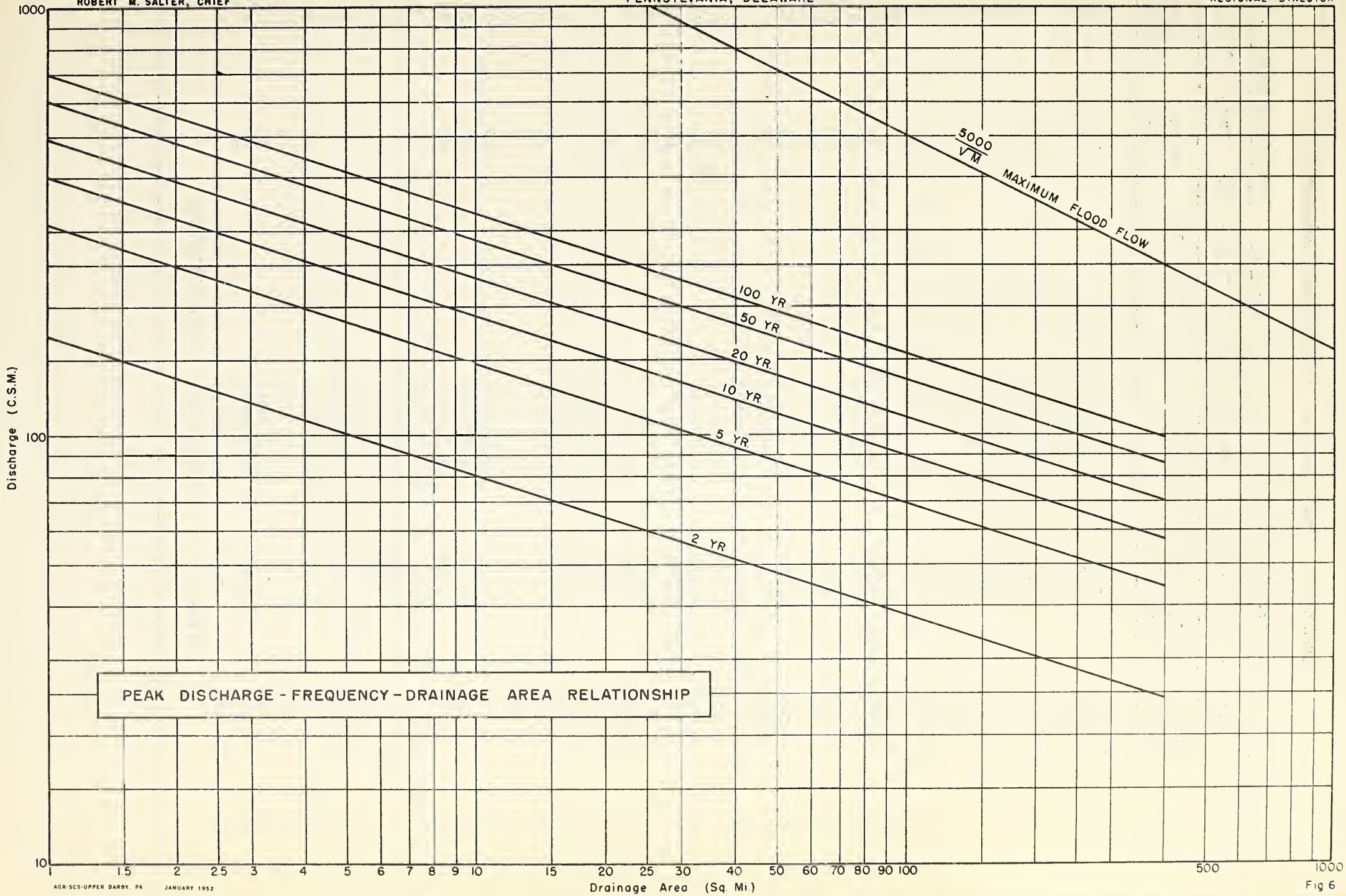

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Fig 6

Table 12. Peak Discharge-Frequency Calculation

Brandywine Creek at Chadds Ford, Pa. D.A. 287 Sq. Mi. Recording Water - Stage

Period of Record - 1912 - 1950 Source of Data - USGS - WSP Date - 7-1-51

Water Year	Peak Q (cfs)	(Log_{10}) of Peak Q	$(\text{Log}_{10})^2$	$(\text{Log}_{10})^3$	Order No.	Plotting Position
1912	10,600	4.025	16.200625		10	24.0
13	3,480	3.542	12.545764		35	85.9
14	3,320	3.521	12.397441		36	88.4
15	28,800	4.459	19.882681		3	6.7
16	2,700	3.431	11.771761		38	93.3
17	4,190	3.622	13.118884		32	78.5
18	14,000	4.146	17.189316		6	14.1
19	7,700	3.886	15.100996		17	41.3
20	30,500	4.484	20.106256		1	1.7
21	2,500	3.398	11.546404		39	95.8
22	3,950	3.597	12.938409		33	81.0
23	3,180	3.502	12.264004		37	91.8
24	7,000	3.845	14.784025		19	46.3
25	8,750	3.942	15.539364		16	38.9
26	5,440	3.736	13.957696		24	58.7
27	7,350	3.866	14.945956		18	43.8
28	10,600	4.025	16.200625		11	26.5
29	6,400	3.806	14.485636		21	51.2
30	4,350	3.638	13.235044		30	73.5
31	9,890	3.995	15.960025		12	29.0
32	4,930	3.693	13.638249		28	68.6
33	25,000	4.398	19.342404		4	9.2
34	4,350	3.638	13.235044		31	76.0
35	7,000	3.845	14.784025		20	48.8
36	11,500	4.061	16.491721		8	19.0
37	3,790	3.579	12.809241		34	83.4
38	12,300	4.090	16.728100		7	16.6
39	9,510	3.978	15.824484		14	33.9
40	6,190	3.792	14.379264		22	53.7
41	5,060	3.704	13.719616		27	66.1
42	29,400	4.468	19.963024		2	4.2
43	5,360	3.729	13.905441		25	61.1
44	9,130	3.960	15.681600		15	36.4
45	9,890	3.995	15.960025		13	31.4
46	11,100	4.045	16.362025		9	21.5
47	2,500	3.398	11.546404		40	98.3
48	6,190	3.792	14.379264		23	56.2
49	5,360	3.729	13.905441		26	63.6
50	4,690	3.671	13.476241		29	71.0
51	17,220	4.236	17.943696		5	11.6
		$\leq$154.267	598.246221	2333.107037941		

Table 12. (Cont'd) Peak Discharge-Frequency Calculation

$$n = 40$$

$$M = \Sigma X/n = 3.857$$

$$\Sigma X^2 = 598.246221$$

$$(\Sigma X)^2/n = 594.957682$$

$$\Sigma(x)^2 = \Sigma X^2 - (\Sigma X)^2/n = 3.288539$$

$$\Sigma(x)^2/n-1 = .084322$$

$$\overline{S} = \sqrt{(x)^2/n-1} = .290$$

$$M + \overline{S} = 4.147 \quad \text{Antilog} = 14{,}030 \text{ Plot at } 15.9\%$$

$$M - \overline{S} = 3.567 \quad \text{Antilog} = 3{,}690 \text{ Plot at } 84.1\%$$

$$\text{Approx. SK (skew)} = \frac{(3)\ (\text{mean} - \text{median})}{\text{Standard Deviation } (5)}$$

$$= \frac{(3)\ (3.857 - 3.826)}{.290} = + .321$$

$$\text{Coefficient of Dispersion} = S = \sqrt{(x)^2/n} = .287$$

$$\text{Cal. SK} = \Sigma(x)^3/n\ S^3 = .500143/(40)(.287)^3 = + .529$$

$$\Sigma(x)^3 = \Sigma(X)^3 - \frac{3(\Sigma X)\ \Sigma(X)^2}{n} + \frac{2(\Sigma X)^3}{n^2}$$

$$\Sigma(x)^3 = 2333.1070379\,41 - \frac{(3)\ (154.267)(598.246221)}{40} + \frac{2(154.267)^3}{(40)^2}$$

$$= 2{,}333.107038 - 6{,}921.723733 + 4{,}589.116838$$

$$\Sigma(x)^3 = .500143$$

Table 13. Land Use by Soil Groups
Brandywine Creek Watershed above Chadds Ford, Pa.

	Deep, Well Drained		Shallow, Well Drained		Imperfectly and Poorly Drained		Total	
	(acres)	(percent)*	(acres)	(percent)*	(acres)	(percent)*	(acres)	(percent)*
				PRESENT				
Clean Tilled	19,295	10.51	5,371	2.92	2,791	1.52	27,457	14.95
Close Growing	38,552	20.99	15,649	8.52	20,046	10.91	74,247	40.42
Good Pasture	16,073	8.75	5,022	2.74	8,988	4.89	30,083	16.38
(All Openland)	73,920	40.25	26,042	14.18	31,825	17.32	131,787	71.75
Good Woodland	6,228	3.39	4,004	2.18	2,920	1.59	13,152	7.16
Fair Woodland	9,515	5.18	6,100	3.32	4,390	2.39	20,005	10.89
Poor Woodland	3,473	1.89	2,260	1.23	1,629	.89	7,362	4.01
(All Woodland)	19,216	10.46	12,364	6.73	8,939	4.87	40,519	22.06
Other	-	-	-	-	-	-	11,374	6.19
TOTAL	93,136	50.71	38,406	20.91	40,764	22.19	183,680	100.00
				FUTURE				
Clean Tilled	21,242	11.57	3,778	2.06	712	.39	25,732	14.02
Close Growing	21,684	11.81	7,786	4.24	7,803	4.25	37,273	20.30
Good Pasture	30,715	16.72	10,916	5.94	20,165	10.97	61,796	33.63
(All Openland)	73,641	40.10	22,480	12.24	28,680	15.61	124,800	67.95
Good Woodland	16,610	9.04	13,500	7.34	10,325	5.62	40,435	22.00
Fair Woodland	2,535	1.38	2,061	1.12	1,532	.84	6,128	3.34
Poor Woodland	350	.19	365	.20	225	.12	940	.51
(All Woodland)	19,495	10.61	15,926	8.67	12,084	6.58	47,503	25,85
Other	-	-	-	-	-	-	11,374	6.19
TOTAL	93,136	50.71	38,406	20.91	40,764	22.19	183,680	100.00

* Percent of total watershed above Chadds Ford, Pa.

Table 14. Summary of Storms Analyzed for Area above Chadds Ford, Pa. Brandywine Creek Watershed, Pennsylvania and Delaware

Investigation Storm Number	Rainfall-Average Depth over Watershed	Rainfall-Maximum Intensity Inches Per Hour	Peak Flow Observed Second Feet	Runoff Observed Average Depth over Waterhsed - Inches	Runoff Calculated Present Conditions	Runoff Calculated Program Assumed to be in Effect	Percent Reduction Determined Due to Complete Program
1	1.82	2.73	4,600	.37	.3724	.3084	17.2
2	2.74	3.54	8,400	.67	.6856	.5964	13.8
3	3.36	3.93	10,800	.88	.8895	.7819	12.1
4	3.94	4.21	13,700	1.10	1.1196	.9959	10.6
5	5.81	4.62	22,200	1.85	1.8828	1.7184	8.7
6	7.52	4.70	29,800	2.50	2.5538	2.3522	7.9
7	9.02	4.76	36,000	3.07	3.1683	2.9279	7.6

The reduction to be expected for flood flows on Brandywine Creek at Chadds Ford, Pennsylvania is shown in Figure 7.

These reductions in runoff and peak flow are calculated to permit a determination of the flood control benefits to be obtained from the recommended program.

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BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR

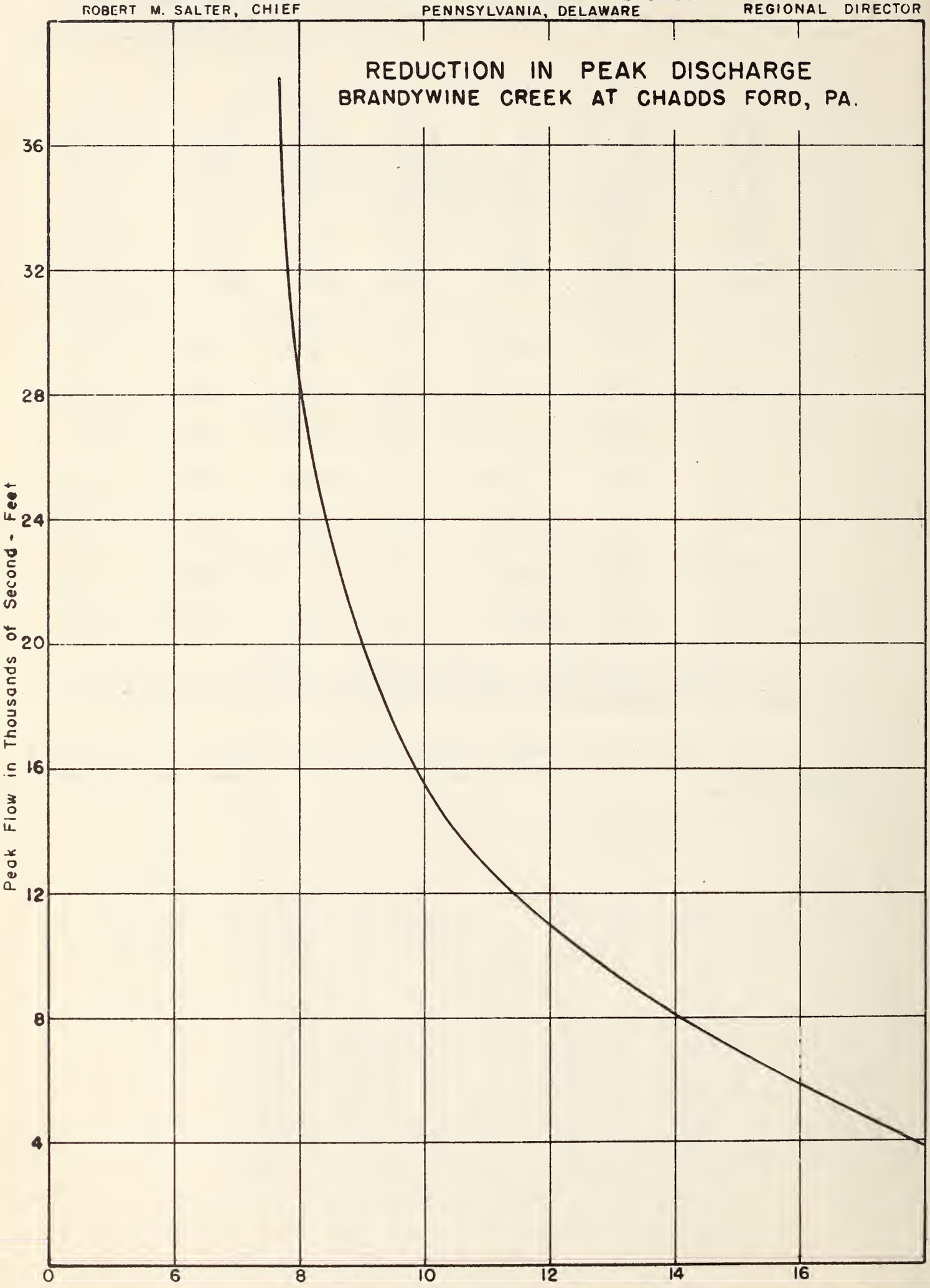

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Fig. 7

Table 15. Runoff Reduction Determination

Brandywine Creek Watershed at Chadds Ford, Pa. D.A. - 287 Square Miles

Storm #4 P = 3.94 in. Y = 1.10 in. Coincidence at 90 min. QP = 13,700 C.F.S. Date 7-24-51

Soil Group	Cover	PRESENT Area %	PRESENT 1st Trial P_e	PRESENT 1st Trial Min. % In.	FUTURE Area %	FUTURE % In.
Deep Well Drained	Row Crops	10.51	.99	10.4049	11.57	11.4543
	Close Growing	20.99	.83	17.4217	11.81	9.8023
	Good Pasture	8.75	.67	5.8625	16.72	11.2024
	Good Woodland	3.39	.30	1.0170	9.04	2.7120
	Fair Woodland	5.18	.55	2.8490	1.38	.7590
	Poor Woodland	1.89	.68	1.2852	.19	.1292
Shallow, Well Drained	Row Crops	2.92	1.39	4.0588	2.06	2.8634
	Close Growing	8.52	1.19	10.1388	4.24	5.0456
	Good Pasture	2.74	1.00	2.7400	5.94	5.9400
	Good Woodland	2.18	.57	1.2426	7.34	4.1838
	Fair Woodland	3.32	.84	2.7888	1.12	.9408
	Poor Woodland	1.23	1.00	1.2300	.20	.2000
Imperfectly and Poorly Drained	Row Crops	1.52	2.07	3.1464	.39	.8073
	Close Growing	10.91	1.86	20.2926	4.25	7.9050
	Good Pasture	4.89	1.56	7.6284	10.97	17.1132
	Good Woodland	1.59	1.07	1.7013	5.62	6.0134
	Fair Woodland	2.39	1.37	3.2743	.84	1.1508
	Poor Woodland	.89	1.63	1.4507	.12	.1956
	Other	6.19	2.17	13.4323	6.19	13.4323
	TOTAL			111.9653		101.8504

$$\frac{111.9653 - 101.8504}{111.9653} = 9.0966\%$$

Reduction due to land use changes only = 9.0966%

Table 16. Runoff Reduction Determination
Effect of Increased Humus on Detention Storage
Brandywine Creek Watershed

	Average Inches Humus Depth	Land Use (% Area)			Depth - % Area Change
		Present	Future	Change	
	(inches)	(%)	(%)	(%)	
Good Woodland	2.87	10.46	22.00	+11.54	+ 33.1198
Fair Woodland	1.58	10.89	3.34	- 7.55	- 11.9290
Poor Woodland	0.73	4.01	0.51	- 3.50	- 2.5550
					+ 18.6358

Effect of humus = (18.6358) (.05 detention storage of increased humus = 0.9318% in.)

Effect of contour measures on detention storage.
67.95 (future openland) .25 (percent of contour tillage) .05 (detention storage) =.8494% in.

Summary:

	Storage (% in.)	Runoff (% in.)
Present Condition of Runoff		111.9653
Effect of Changes in Land Use Only	10.1149	
Effect of Woodland Humus Detention	.9318	
Effect of Contour Measures on Detention	.8494	
Total Effect	11.8961	100.0692

Total effect of recommended land treatment program:

$$\frac{111.9653 - 100.0692}{111.9653} = 10.6\% \text{ reduction}$$

SECTION IV - DAMAGES

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DAMAGES

Flood Damage

To facilitate damage appraisal the waterways of the Brandywine were classified (1) main stream, which included the reach from Wilmington to the junction of the East and West Branches; (2) the East Branch; (3) West Branch; and (4) minor tributaries.

Studies were made of available information from federal, state and local agencies. Reconnaissance field investigations were made to determine on which streams damages were significant and to what extent they had been appraised.

The damage appraisals were based primarily on past floods and referenced to flood stage, discharge and frequency. Direct and indirect damages were evaluated and consideration was given to intangible losses. In estimating the damages, property owners were interviewed to ascertain the types and quantity of property damage by given flood stages and the amount of damage by types of property affected. The following tables indicate the results of this appraisal:

Table 17. Estimated Damage from Floods of Specified Probable Chance of Occurrence Brandywine Creek Watershed

Reach	Probable Number of Occurrences in 100-Year Period				
	100	20	10	5	1
	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)
Main Stem	-	12,600	25,600	37,000	71,000
East Branch	-	1,210	4,715	49,725	218,900
West Branch	-	90,770	293,210	607,400	1,717,050
Minor Tributaries	290	8,630	12,200	17,875	24,600
TOTAL	290	113,210	335,725	712,000	2,031,550

Table 18. Estimated Damage from Floods of Record Brandywine Creek Watershed

Reach	1950 Flood	1942 Flood
	(dollars)	(dollars)
Main Stem	21,500	67,000
East Branch	5,500	207,000
West Branch	1,000	1,458,000
Minor Tributaries	12,000	18,000
TOTAL	40,000	1,750,000

Table 19. Average Annual Flood Damage by Type
Brandywine Creek Watershed

Reach	Industrial	Commercial	Residential	Highway & Railroad	Agricultural	Other	Total
	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)
Main Stem	3,420	2,260	260	1,870	360	-	8,170
East Branch	6,730	1,050	870	720	30	840	10,240
West Branch	98,240	10	650	90	230	-	99,220
Minor Tributaries	250	870	260	440	1,550	-	3,370
TOTAL	108,640	4,190	2,040	3,120	2,170	840	121,000

Table 20. Average Annual Flood Damage
Brandywine Creek Watershed

Stream Reach	Average Annual Damage	
		(dollars)
Main Stem:		
Wilmington and Rockland	3,420	
Rockland to Lenape Park	2,600	
Lenape Park and Vicinity	2,150	
Subtotal		8,170
East Branch:		
Mouth to Downingtown	400	
Downingtown and Vicinity	9,350	
Downingtown Upstream	490	
Subtotal		10,240
West Branch:		
Mouth to Modena	250	
Coatesville and Vicinity	97,910	
Coatesville Upstream	1,060	
Subtotal		99,220
Other Tributaries:		
Valley Creek	1,490	
Beaver Creek	360	
Buck and Doe Runs	140	
Minor Tributaries	1,380	
Subtotal		3,370
TOTAL		121,000

Sheet and Gully Erosion

The extent and severity of erosion in the watershed is shown in Table 21. The relation of erosion to land slope is indicated in Table 22.

Table 21. Extent and Severity of Sheet and Gully Erosion
Brandywine Creek Watershed

Degree of Erosion	Percentage of Watershed
No apparent or slight erosion (less than 25% of topsoil removed)	31.5
Moderate erosion (25 to 75% of topsoil removed)	43.8
Severe erosion (75 to 100% of topsoil and less than 25% of subsoil removed)	22.6
Very severe erosion (all topsoil and 25 to 75% of subsoil removed)	2.0
Very severely gullied land (all topsoil and 75% or more of the subsoil removed)	.1
	100.0

Table 22. Extent and Severity of Sheet and Gully Erosion
by Land Slope Classes
Brandywine Creek Watershed

Degree of Erosion	Slope of Land in Percent					
	0 - 3	3 - 8	8 - 15	15 - 25	25 - 35	Over 35
	(percent of slope class by degree of erosion)					
No apparent or slight erosion	92.5	17.0	10.8	32.3	39.0	-
Moderate erosion	7.5	77.8	29.6	15.8	17.1	16.7
Severe erosion	-	5.0	58.3	43.6	31.7	66.6
Very severe erosion	-	0.2	1.3	8.3	9.8	16.7
Very severely gullied land	-	-	-	-	2.4	-
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

The average annual soil loss by problem areas is indicated in Table 23.

Table 23. Average Annual Soil Loss by Problem Areas
Brandywine Creek Watershed

Problem Area		Av. Annual Soil Loss		
Map Symbol	Name	Acres	Acre-Feet	Tons
1	North Valley Hills	14,418	29	55,400
2	Honeybrook & Chester Springs	71,814	113	216,200
3	Beaver Dam	2,600	7	12,900
4	Chester Valley and Doe Run	11,612	17	33,200
5	Octoraro & South Valley Hills	39,958	102	195,800
6	Oxford Malvern	27,116	50	96,000
7	West Chester Wilmington Hilly Piedmont	43,187	79	151,400
8	Jersey Delmar Coastal Plain	495	0	0
	Total Watershed	211,200	397	760,900

Soil erosion has affected farm income in several ways. In many instances it has reduced crop and pasture yields. In others it has increased the costs of crop production by making necessary the application of greater quantities of fertilizer. Because of soil erosion, maximum yields have not been obtained through the greater use of improved seeds, insecticides and cultural practices. If soil erosion continues at its present rate, it will cost the farmers of the watershed an annual incremental sum of $12,500. This is equivalent to $1,250,000 over a 20-year period.

Streambank Erosion

A survey of the streambanks in the watershed indicated that 35,000 tons (18.7 acre-feet) of soil are eroded annually. Most of the erosion takes place along the streams meandering through pastures where protective vegetative growth has been destroyed by overgrazing. Streambank erosion is the source of 18 percent of the dredged material from Wilmington Harbor. This source of sedimentation represents an annual dredging cost of $6,600.

Tables 24 and 25 show the extent, severity, rate and location of streambank erosion, as determined by the field survey.

Table 24. Present Area and Severity of Eroded Streambanks by Type of Stream Brandywine Creek Watershed

Type of Stream	Square Feet of Banks by Erosion Class 1/				
	Normal	Moderate	Severe	Very Severe	All Classes
Main Stem	18,100	41,200	28,500	5,300	93,100
East and West Branches	51,600	170,200	155,600	227,700	605,100
First Order Tributaries	38,200	152,200	158,300	462,600	811,300
Second Order Tributaries	160,100	294,900	835,200	935,200	2,225,400
All Streams	268,000	658,500	1,777,600	1,630,800	3,734,900

1/ Normal Erosion - No visible evidence or insignificant evidence of erosion.
Moderate Erosion - Cutting slowly enough that trees have time to grow support roots.
Severe Erosion - Raw banks that show erosion with no undercutting. Bank slopes vary from 60-90 degrees.
Very Severe Erosion - Banks that are undercutting slope of banks approximately 90 degrees.

Table 25. Annual Soil Loss from Streambanks by Type of Stream Brandywine Creek Watershed

Type of Stream	Length of Stream		Quantity of Erosion	
	Miles	Percent of Total	Tons	Percent of Total
Main Stem	19	3.3	1,407	4.0
East and West Branches	47	8.2	11,774	34.0
First Order Tributaries	72	12.6	14,847	43.0
Second Order Tributaries	435	75.9	6,554	19.0
All Streams	573	100.0	34,582	100.0

Sedimentation Damage

Reservoirs. A summary of the pertinent data concerning sedimentation in Rock Run and Icedale reservoirs, as determined by field surveys, is shown in Table 26. Figure 8 depicts cross sectional views of the Rock Run reservoir, indicating the damage caused by deposition.

Table 26. Sedimentation in Rock Run and Icedale Reservoirs
Brandywine Creek Watershed

Results of Survey	Unit	Rock Run Reservoir	Icedale Reservoir
Age	Years	35	51
Drainage Area	Sq.Mi.	5	20
Reservoir Data:			
Area:			
Original	Acres	61	26
Present	"	60	25
Storage Capacity at Crest Elevation:			
Original	Ac.Ft.	1,019	137
Present	"	970	106
Capacity Per Sq. Mi. of Drainage Area:			
Original	Ac.Ft.	204	6.8
Present	"	194	5.3
Sedimentation:			
Total Sediment	Ac.Ft.	49	31.1
Average Annual Sediment Accumulation	"	1.4	.6
Per Sq. Mi. of Drainage Area	"	.28	.03
Per Acre of Drainage Area	Cu.Ft.	19	2.08
By Weight 1/	Tons	.47	.05
Depletion of Storage Capacity:			
Per Year	Percent	.14	.40
To Date of Investigation	"	4.80	22.7

1/ Assuming 1 cubic foot of sediment weighs 50 pounds.

Cross sections of two old diversion dams are shown in Figure 9. Sedimentation has practically destroyed their usefulness. These old reservoirs are typical of many others in the Brandywine Creek Watershed.

Wilmington Harbor. The estimated annual cost of $36,700 for removing the portion of the sediment in Wilmington Harbor that is caused by Brandywine Creek was based on records of suspended sediment in the creek at Wilmington.

Table 27 indicates the method used in determining the annual quantity of eroded material deposited in the harbor. The mean daily flow in the Brandywine Creek at Chadds Ford was related to the amount of recorded sediment in suspension at Wilmington. The number of days in the year at which these flows occur were associated with the quantity of suspended sediment to determine the annual quantity carried.

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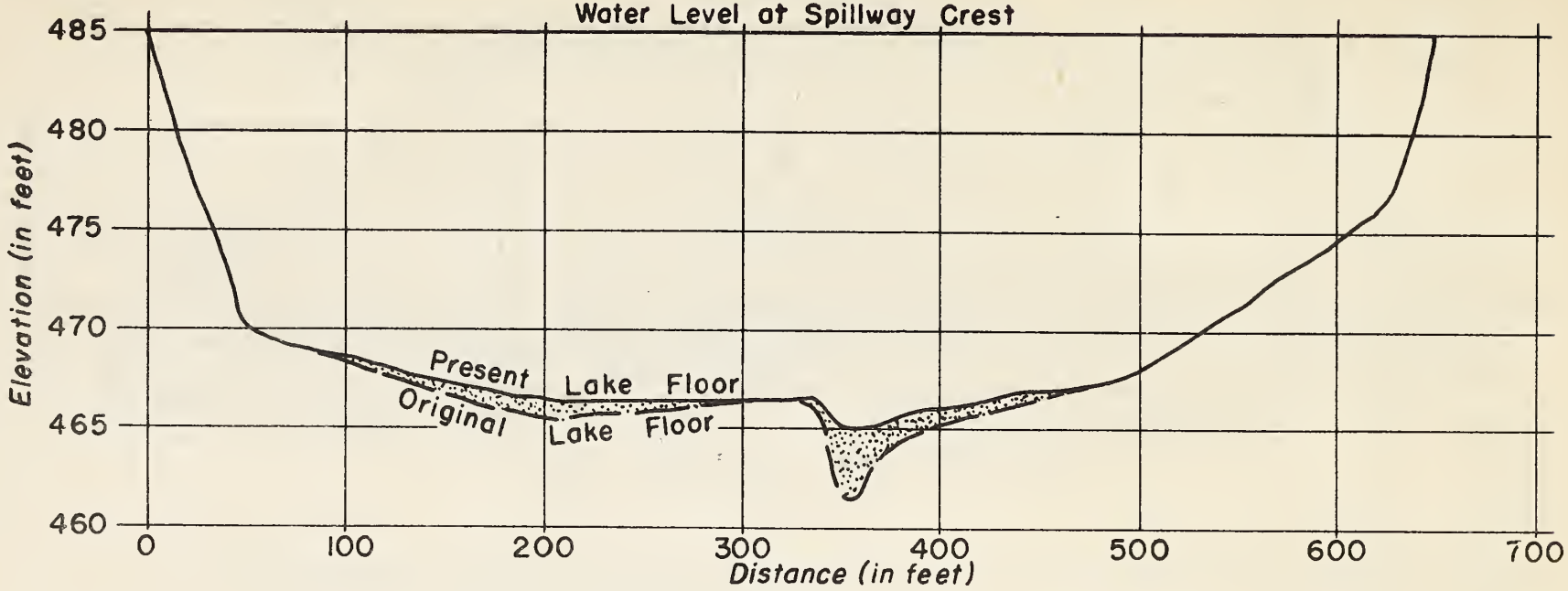
ROCK RUN RESERVOIR - COATESVILLE, PENNA.

RANGE 5-6

Water Level at Spillway Crest



RANGE 7-8

Water Level at Spillway Crest

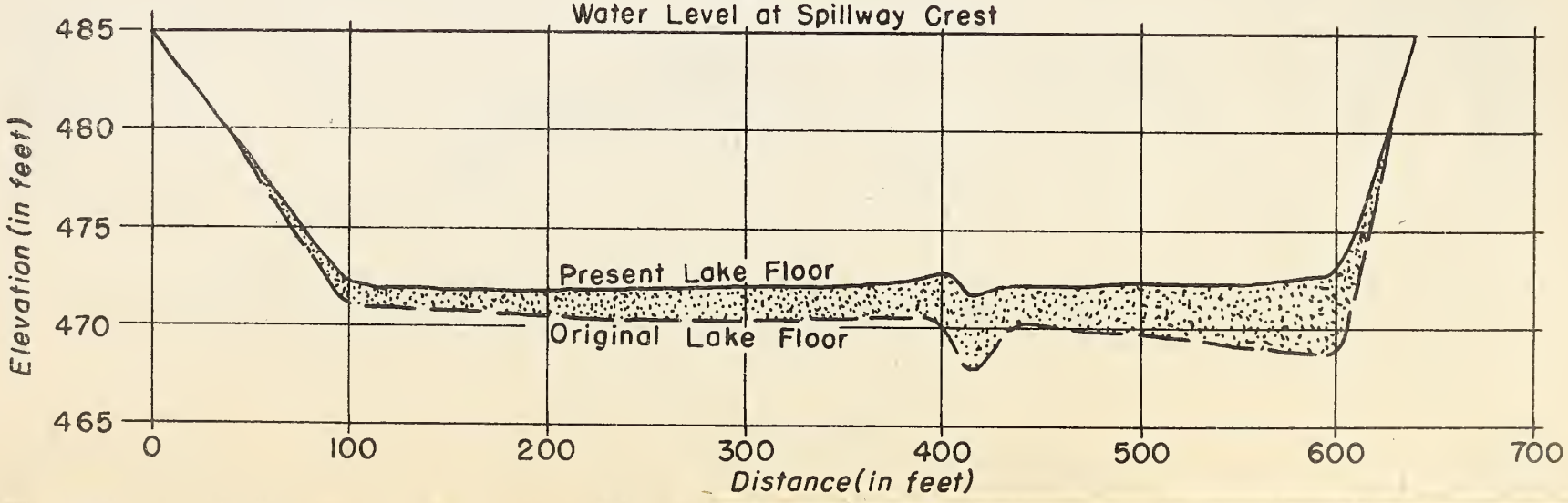


Fig. 8

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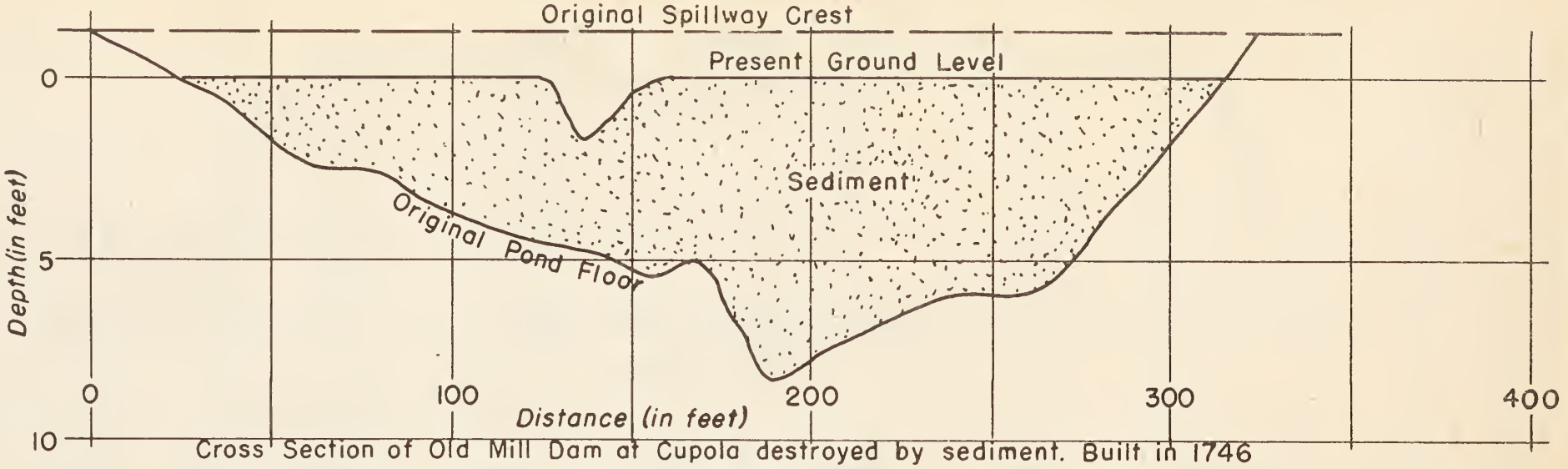
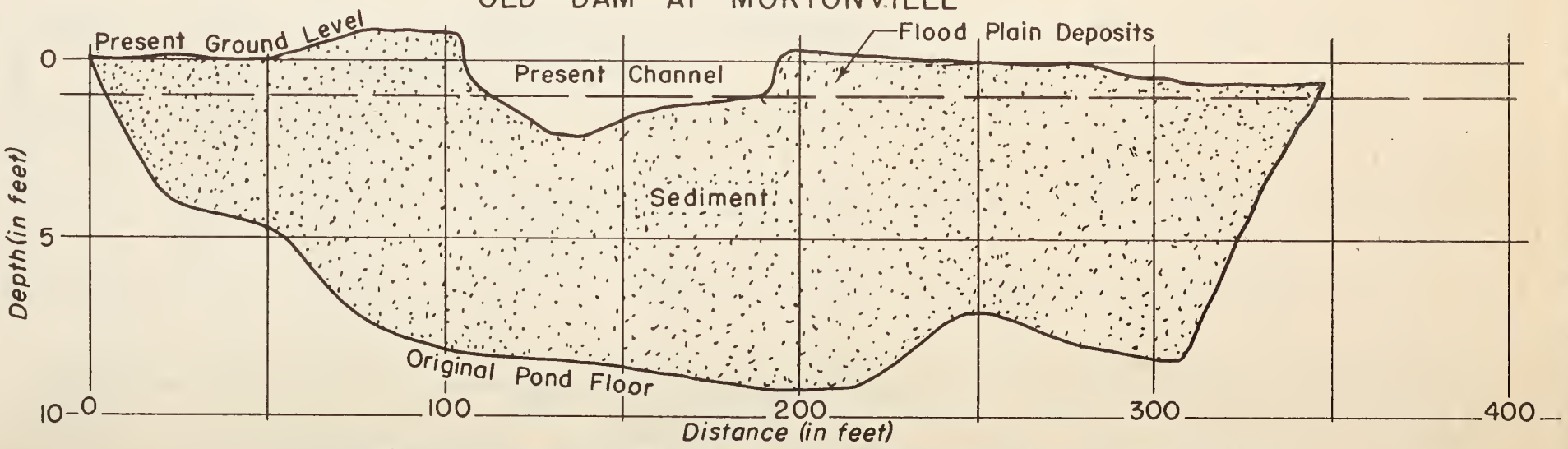
OLD DAM AT CUPOLA



Cross Section of Old Mill Dam at Cupola destroyed by sediment. Built in 1746

OLD DAM AT MORTONVILLE



Cross Section of Old Lake at Mortonville, Pa. It is completely filled with sediment. The west branch still carries much sediment as evidenced by the flood plain deposits On top of the Old Lake sediment.

Fig. 9

The greatest sediment load does not always occur at the highest discharge. The amount of sediment carried is influenced by many conditions, such as intensity and duration of storm, amount of vegetative cover on the watershed at the time of storm, and seasonal occurrence.

Table 27. Suspended Sediment Carried by Brandywine Creek at Wilmington, Delaware

Mean Daily Flow	Number of Days Per Year at Indicated Flow	Tons of Sediment Per Day at Indicated Flow	Tons of Sediment Per Year
50	17.105	25	428
150	96.292	25	2,407
250	94,393	25	2,360
350	58.312	28	1,633
450	35,261	37	1,305
550	18.843	32	603
650	11.396	44	501
750	7.816	68	532
850	5.369	71	381
950	3.711	128	475
1,050	2.528	212	536
1,150	2.104	300	631
1,250	1.947	500	974
1,350	1.340	750	1,005
1,450	.946	900	851
1,550	.920	1,000	920
1,650	.920	1,200	1,104
1,750	.526	1,300	684
1,850	.369	1,475	544
1,950	.632	1,750	1,106
2,250	1.709	2,500	4,273
2,750	1.183	4,300	5,087
3,250	.475	7,100	3,373
3,750	.343	10,000	3,430
4,500	.394	12,500	4,925
5,500	.183	15,000	2,745
6,500	.051	18,500	944
8,500	.080	26,600	2,128
10,300	.026	35,300	918
12,300	.025	45,700	1,144
13,200	.026	50,700	1,318
16,100	.025	65,300	1,633
	365,250		50,898

SECTION V - PLAN OF IMPROVEMENT

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The plan of improvement consists of a coordinated watershed program for waterflow retardation and soil erosion prevention. Included in the program are certain land use adjustments based on the capability of the land and the necessary land treatment practices and measures described below.

Cropland Treatment

To provide for the improvement and conservation of cropland in the watershed by reducing runoff and erosion, the following treatment is recommended.

Contour Farming. The planting or drilling of crops on the contour following established contour lines. By providing temporary surface storage, this practice will reduce the rate and amount of runoff and resulting sheet and gully erosion.

Crop Rotations. The growing of different crops in regular succession on the same land as contrasted to a one-crop system. A rotation should follow the principle of alternating cultivated crops with semi-erosion resisting (small grain) and erosion resisting (hay) crops. This practice will result in improved tilth, moisture holding capacity and fertility of the soil and will provide increases in quality and quantity of production.

Cover Cropping. Growing temporary crops following the harvesting of clean tilled crops to provide vegetative cover on the land until the next regular crop is planted. This vegetative cover will provide protection to the soil from runoff and erosion during the critical periods between regular crops.

Crop Residue Management. The management of cropland to conserve stubble and other crop aftermath on or near the surface of the soil. This practice will reduce wind and water erosion, conserve moisture, decrease evaporation and will result in increased production.

Contour Strip Cropping. The growing of hay in alternate contour strips with clean tilled crops or small grain crops. Contour strip cropping will reduce the rates and amounts of runoff by providing temporary surface storage and increasing infiltration rates.

Diversions and Terraces. Diversions and terraces are grouped as one measure because they have the same general function: intercepting surface runoff and carrying it across slopes in designed channels. Diversions are normally kept in perennial hay, while terraces are used for the same crop as the contiguous land. Both diversions and terraces are used in connection with strip cropping and contour cultivation for removing excess surface water.

Outlets and Farm Watercourses. The use of natural drainageways or constructed outlets for disposing of concentrated runoff water. They are usually stabilized and protected by a permanent grass cover. Additional protection measures, such as drop structures, chutes or flumes may be used where required. This measure will reduce gully erosion and the resulting sedimentation damage. It will also facilitate the construction of diversions and terraces by providing a protected outlet for such measures.

Establishing Perennial Hay. The establishment of a perennial vegetative cover consisting of long-lived legumes and grasses suitable for hay on those areas where clean tilled crops cannot be safely grown in rotation. Reseeding of this perennial cover will be done at infrequent intervals with as little cultivation of the land as possible. Perennial hay will reduce sheet and gully erosion, increase infiltration rates and reduce runoff. In addition, the quantity and quality of hay production will be improved.

Pastureland Treatment

To provide for improved quality and quantity of pasture forage and to reduce runoff by improving the hydrologic condition of pastureland, the following treatment is recommended.

Pasture Improvement. The practice of liming, fertilizing and reseeding present permanent pastureland in accordance with its needs. This improved pasture will provide increased forage and result in reduced runoff due to increased infiltration rates.

Establishing Pasture. The establishment of new pastureland converted from cropland, woodland or idle land. This practice involves seeding, liming and fertilizing. The establishment of this new pasture will provide increased forage and result in reduced runoff due to increased infiltration rates.

Fencing. The construction of new permanent fences which will be required because of field rearrangements and land use conversions.

Pasture Management. The development and maintenance of an adequate vegetative cover on pastureland by mowing to control weeds and remove mature grasses, by scattering of droppings and by regulating the intensity of grazing. This practice will, in addition to providing increased forage, reduce runoff by increasing the infiltration rate.

Contour Furrowing. The construction of level furrows or small level terraces on pastureland. Contour furrows will provide detention storage and result in decreased runoff and erosion.

Woodland Treatment

To provide for the safeguarding and improvement of watershed values of forest and woodland and to improve economic values, the following treatment is recommended.

Woodland Grazing Protection. The protection of woodlands from grazing and fire. Protection from grazing may involve the construction of wire fence, the planting and development of multiflora rose fence, or the rearrangement of fields to keep stock out of the woodland.

Woodland Fire Protection. Maintain the present efficiency in fire protection. Improve by educational and informational means public interest in the voluntary support of fire prevention and suppression efforts.

Woodland Improvement. The cutting or girdling of weed trees or imperfectly formed trees to develop a satisfactory growing stock that will result in developing and improving woodland products.

Woodland Harvest Cutting. The harvesting of woodland products in such a manner as to insure stand improvement in accordance with accepted forestry practices, and to conserve soil and moisture.

Tree Planting. The planting of tree seedlings on certain areas of openland recommended for conversion to woodland, and in open areas of woodland to improve stand density. Runoff and erosion will be reduced on the reforested areas.

Wildlife

Wildlife Area Improvement. Provides for the improvement of habitat conditions on areas devoted to wildlife use by plantings of shrubs and trees and protection from grazing.

Borders. The establishment of wildlife borders by cutting or by planting of strips of shrubs and/or herbaceous perennial plants in the areas or margins between woodlands (including newly planted trees) and cultivated, hay or pasture fields. This practice provides wildlife cover for the unproductive areas next to woodlands and helps to control erosion and reduce the effects of wind in the woodland.

Hedges. The planting or seeding of lines of shrubs across open fields or along boundaries between two open fields. The primary purpose of hedges is to provide well distributed wildlife cover. Hedges across open fields are usually on the contour.

Fish Pond Management. This practice involves the elimination of undesirable fish population and leafy aquatic plants, the stocking of suitable fish, and following an adequate fertilization program.

Drainage

Open Drains. The removal of excess surface or ground water from agricultural lands by the use of bedding, open V-type ditches, or other open drains.

Covered Drains. The removal of excess surface or ground water from agricultural lands by the use of clay tile, porous pipe, closed rock drains, or other covered drains. The proper installation of farm drainage will result in increased production and better land use.

Miscellaneous Measures

Farm Ponds. Water impoundments of two general types: (1) An earth fill dam across a ravine or draw through which a small outlet conduit will be constructed to handle the normal flow from the drainage area above. An emergency spillway, adapted to site conditions, will be used to provide a safe outlet for flood flows; and (2) an excavated pond area with little or no drainage area above. The source of water is usually a nearby spring or stream with the amount entering the pond controlled by a small inlet conduit.

Farm ponds are used primarily to provide stock water, fire protection, and recreational facilities.

Clearing and Obstruction Removal. The clearing of brush from land and removal of other obstructions to permit and facilitate the installation of other measures and practices.

Windbreak Planting. The planting of shrubs and trees in strips or lines, usually from one to 10 rows wide, to influence wind currents.

This practice will help control snow drifting and will provide wind protection for crops, livestock, orchards and buildings.

Channel Improvement. The improvement of channel conditions by clearing, snagging or excavating to increase the capacity of the channel at bank-full stage and reduce the frequency of flooding.

Table 28. Present and Future Land Use
Welsh Mt., Barren Ridge and North Valley Hills Problem Area
Brandywine Creek Watershed

Present Land Use	Future Land Use						
	Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:							
Cropland	4,477	3,716	112	452	197	-	-	-
Pasture	1,374	-	183	384	367	-	440	-
Woodland	1,194	26	10	-	1,158	-	-	-
Miscellaneous	1,628	129	-	-	856	-	643	-
Total Farmland	8,673	3,871	305	836	2,578	-	1,083	-
Non-Farmland:							
Woodland	4,357	-	-	-	4,357	-	-	-
Miscellaneous	523	-	-	-	56	82	385	-
Highways, Roads, Streams, etc.	865	-	-	-	-	-	-	865
Total Non-Farmland	5,745	-	-	-	4,413	82	385	865
TOTAL	14,418	3,871	305	836	6,991	82	1,468	865

Table 29. Present and Future Land Use
Honeybrook Problem Area
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	25,869	18,418	3,337	2,665	854	103	492	-
Pasture	10,011	180	270	9,161	290	30	80	-
Woodland	7,532	23	7	279	7,072	83	68	-
Miscellaneous	6,582	559	263	1,961	961	902	1,936	-
Total Farmland	49,994	19,180	3,877	14,066	9,177	1,118	2,576	-
Non-Farmland:								
Woodland	10,573	-	-	-	10,573	-	-	-
Miscellaneous	6,938	-	-	-	749	1,082	5,107	-
Highways, Roads, Streams, etc.	4,309	-	-	-	-	-	-	4,309
Total Non-Farmland	21,820	-	-	-	11,322	1,082	5,107	4,309
TOTAL	71,814	19,180	3,877	14,066	20,499	2,200	7,683	4,309

Table 30. Present and Future Land Use
Beaver Dam Problem Area
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	1,141	1,090	-	51	-	-	-	-
Pasture	356	12	-	336	8	-	-	-
Woodland	105	-	-	1	104	-	-	-
Miscellaneous	159	27	57	2	51	-	22	-
Total Farmland	1,761	1,129	57	390	163	-	22	-
Non-Farmland:								
Woodland	547	-	-	-	547	-	-	-
Miscellaneous	162	-	-	-	17	25	120	-
Highways, Roads, Streams, etc.	130	-	-	-	-	-	-	130
Total Non-Farmland	839	-	-	-	564	25	120	130
TOTAL	2,600	1,129	57	390	727	25	142	130

Table 31. Present and Future Land Use
Chester Valley and Doe Run
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	4,093	4,023	70	-	-	-	-	-
Pasture	2,401	60	-	2,163	29	29	120	-
Woodland	1,438	-	-	-	1,438	-	-	-
Miscellaneous	1,160	19	75	96	96	225	649	-
Total Farmland	9,092	4,102	145	2,259	1,563	254	769	-
Non-Farmland:								
Woodland	531	-	-	-	531	-	-	-
Miscellaneous	1,083	-	-	-	117	169	797	-
Highways, Roads, Streams, etc.	906	-	-	-	-	-	-	906
Total Non-Farmland	2,520	-	-	-	648	169	797	906
TOTAL	11,612	4,102	145	2,259	2,211	423	1,566	906

Table 32. Present and Future Land Use
Octoraro and South Valley Hills Problem Area
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	14,701	9,982	2,852	1,411	309	-	147	-
Pasture	5,503	176	105	5,095	72	-	55	-
Woodland	3,381	-	3	203	3,125	20	30	-
Miscellaneous	4,685	515	707	1,363	1,017	211	872	-
Total Farmland	28,270	10,673	3,667	8,072	4,523	231	1,104	-
Non-Farmland:								
Woodland	4,792	-	-	-	4,792	-	-	-
Miscellaneous	4,496	-	-	-	486	701	3,309	-
Highways, Roads, Streams, etc.	2,400	-	-	-	-	-	-	2,400
Total Non-Farmland	11,688	-	-	-	5,278	701	3,309	2,400
TOTAL	39,958	10,673	3,667	8,072	9,801	932	4,413	2,400

Table 33. Present and Future Land Use
Oxford-Malvern Problem Area
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	8,626	6,185	1,199	1,026	121	9	86	-
Pasture	7,469	105	456	6,243	620	15	30	-
Woodland	3,123	41	28	167	2,784	75	28	-
Miscellaneous	2,620	217	485	1,292	312	63	251	-
Total Farmland	21,838	6,548	2,168	8,728	3,837	162	395	-
Non-Farmland:								
Woodland	1,202	-	-	-	1,202	-	-	-
Miscellaneous	2,426	-	-	-	262	378	1,786	-
Highways, Roads, Streams, etc.	1,650	-	-	-	-	-	-	1,650
Total Non-Farmland	5,278	-	-	-	1,464	378	1,786	1,650
TOTAL	27,116	6,548	2,168	8,728	5,301	540	2,181	1,650

Table 34. Present and Future Land Use
West Chester Problem Area in Pennsylvania
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	9,688	5,705	1,657	1,473	320	97	436	-
Pasture	7,385	177	244	6,543	199	74	148	-
Woodland	1,446	-	100	12	1,156	84	94	-
Miscellaneous	5,403	124	97	708	1,345	832	2,297	-
Total Farmland	23,922	6,006	2,098	8,736	3,020	1,087	2,975	-
Non-Farmland:								
Woodland	1,869	-	-	-	1,869	-	-	-
Miscellaneous	2,845	-	-	-	307	444	2,094	-
Highways, Roads, Streams, etc.	2,118	-	-	-	-	-	-	2,118
Total Non-Farmland	6,832	-	-	-	2,176	444	2,094	2,118
TOTAL	30,754	6,006	2,098	8,736	5,196	1,531	5,069	2,118

Table 35. Present and Future Land Use
West Chester Problem Area in Delaware
Brandywine Creek Watershed

Present Land Use		Future Land Use						
		Cropland	Permanent Hay	Pasture	Woodland	Wildlife	Miscel-laneous	Imper-vious
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Farmland:								
Cropland	3,646	2,570	373	541	140	22	-	-
Pasture	1,655	-	22	1,628	-	-	5	-
Woodland	1,331	-	-	-	1,331	-	-	-
Miscellaneous	1,732	-	-	-	208	195	1,329	-
Total Farmland	8,364	2,570	395	2,169	1,679	217	1,334	-
Non-Farmland:								
Woodland	1,804	-	-	-	1,804	-	-	-
Miscellaneous	928	-	-	-	232	-	696	-
Highways, Roads, Streams, etc.	1,337	-	-	-	-	-	-	1,337
Total Non-Farmland	4,069	-	-	-	2,036	-	696	1,337
TOTAL	12,433	2,570	395	2,169	3,715	217	2,030	1,337

Table 36. Present and Future Land Use
Coastal Plain Problem Area
Brandywine Creek Watershed

Present Land Use	(acres)	Future Land Use
Farmland:		
None		
Non-Farmland:		
Highways, Roads, Streams, etc.	495	No Change in Future
TOTAL	495	

Table 37 shows the estimated quantities of the various practices and measures required by problem areas (see Problem Area Map) and by states.

In planning the engineering measures required to alleviate the flood problems in the vicinity of Coatesville, Downingtown and Lenape, all possible methods of control were considered. Channel improvement for the Coatesville and Downingtown problems and diking at Lenape were determined to be the most feasible methods.

The problem at Downingtown is inadequate channel capacity underneath and in the vicinity of the bridge carrying Route 322 across the East Branch in the vicinity of the Davey Paper Company. Deposition has so restricted the channel at this point that under present conditions flooding can be expected at frequent intervals. (See Damage-Frequency Curve under Program Appraisal). The recommended plan of improvement consists of the removal of approximately 6,000 cubic yards of material from the channel. The excavated material should be deposited well back from the banks upstream from the bridge, or high water may carry it back into the channel. Below the bridge the excavated material may be deposited along the top of the new bank in the form of a dike. This dike, however, should be contiguous with the fill under the northern approach to the bridge.

At Coatesville the major problem is inadequate channel capacity through the Lukens Steel Company plant, caused primarily by 3 low dams in the channel that are used for low head impoundments. The removal of the low dams and 3,700 cubic yards of excavation to improve the channel gradient are recommended. It will also be necessary, in connection with this plan, to develop a new system for impounding or storing water that would not impede flood flows through the plant. This can be done by using concrete sumps off to one side of the main channel or by improving an existing impoundment upstream.

Another flood hazard exists in the Lukens Steel Company property from Sucker Run, a small tributary of the West Branch. A steel trash rack and concrete collecting basin are recommended for installation above the Lukens Steel Company buildings to remove the debris load. Sucker Run passes under several of the plant buildings in a closed conduit, and the collection of debris at the conduit entrance during periods of high flow, would create a definite hazard.

The installation of 1600 feet of earth dike is recommended along the east bank of the Brandywine at Lenape Park. This dike will complement an existing concrete flood wall in protecting the park from out-of-bank flood flows.

The plan of improvement recommends approximately 33 miles of streambank erosion control. This work will include 13.2 acres of shrub planting, 53 miles of fencing, and 6500 square yards of rock riprap protection.

Table 37. Land Treatment Measures Recommended for Brandywine Creek Watershed
By Problem Areas and States

		PENNSYLVANIA								DELAWARE	WATERSHED TOTAL
Problem Areas 1/ -		1	2	3	4	5	6	7	Total	7	
Number of Farms -		124	423	9	59	521	171	241	1,348	97	1,445
	(unit)										
Cropland Treatment:											
Contour Farming	Acres	154	1,027	57	182	661	353	344	2,778	122	2,900
Crop Rotations	Acres	2,410	17,984	653	3,951	9,856	6,058	5,932	46,844	1,655	48,499
Cover Cropping	Acres	621	3,076	1,518	1,059	2,370	1,453	1,333	11,430	570	12,000
Crop Residue Management	Acres	1,662	11,967	864	3,128	5,263	2,440	4,198	29,522	-	29,522
Contour Strip Cropping	Acres	2,604	18,930	1,134	3,622	12,857	6,790	6,726	52,663	2,284	54,947
Diversions and Terraces	Miles	0.8	36.0	4.3	15.6	7.2	18.3	7.1	89.3	2.6	91.9
Outlets & Farm Watercourses	Acres	34	181	14	42	107	57	75	510	-	510
Establishing Perennial Hay	Acres	305	3,735	57	75	3,667	2,168	1,953	11,960	395	12,355
Pastureland Treatment:											
Pasture Improvement	Acres	266	4,480	72	720	1,960	2,736	2,655	12,889	211	13,100
Establishing Pasture	Acres	483	4,615	134	-	2,693	2,859	1,875	12,659	541	13,200
Fencing	Rods	7,452	51,609	990	9,797	38,401	22,299	4,122	134,670	2,605	137,275
Pasture Management	Acres	836	14,166	385	2,259	6,466	8,719	8,256	41,087	1,650	42,737
Contour Furrows	Acres	-	281	-	-	101	105	176	663	-	663
Woodland Treatment:											
Woodland Grazing Protection	Acres	268	1,694	22	326	761	704	326	4,101	299	4,400
Woodland Fire Protection	Acres	2,704	24,305	883	2,722	11,303	5,861	4,049	51,827	2,475	54,302
Woodland Improvement	Acres	6,800	19,003	717	-	8,646	3,758	2,920	41,844	2,262	44,106
Woodland Harvest Cutting	Acres	585	1,004	-	-	992	1,733	681	4,995	325	5,320
Tree Planting	Acres	267	1,758	-	65	1,432	579	1,639	5,740	310	6,050
Wildlife:											
Wildlife Area Improvement	Acres	200	1,319	47	148	613	318	219	2,864	136	3,000
Borders	Acres	220	180	1	17	212	65	180	875	75	950
Hedges	Miles	20	45	6	30	50	60	63	274	18	292
Fish Pond Management	Acres	8	120	3	6	18	18	29	202	18	220
Drainage:											
Open Drains	Miles	-	29.7	2.5	19	6.9	12.2	6.7	77.0	1.6	78.6
Covered Drains	L.Ft.	4,005	107,657	-	29,206	37,194	41,866	18,692	238,620	5,031	243,651
Miscellaneous Measures:											
Farm Ponds	No.	27	196	10	29	72	71	60	465	35	500
Clearing & Obstruction Removal	Acres	192	2,844	135	-	1,135	628	606	5,540	58	5,598
Windbreak Planting	Miles	3	17	1	3	10.5	6.5	6	47	3	50
Channel Improvement	L.Ft.	-	5,000	-	-	4,000	500	500	10,000	-	10,000

1/ Problem Area 8 entirely urban.

While the plan of improvement does not include water impoundments other than farm ponds, there is marked interest in such structures for recreational use. Eight impoundment sites, shown in Figure 2 of the main part of the work plan, were surveyed.

The data from these surveys are tabulated in Table 38.

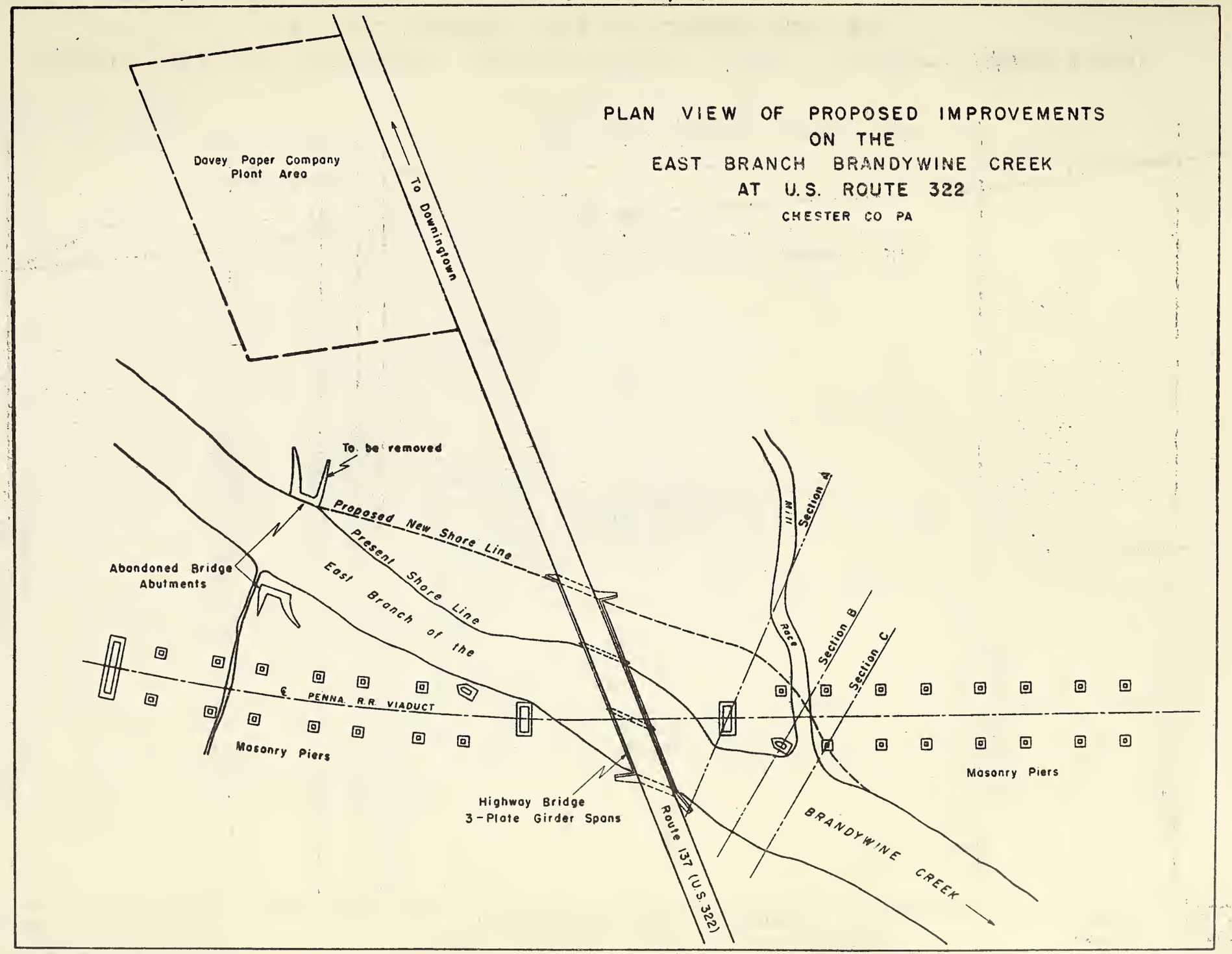
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ROBERT M. SALTER, CHIEF

BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR

PLAN VIEW OF PROPOSED IMPROVEMENTS ON THE EAST BRANCH BRANDYWINE CREEK AT U.S. ROUTE 322

CHESTER CO PA



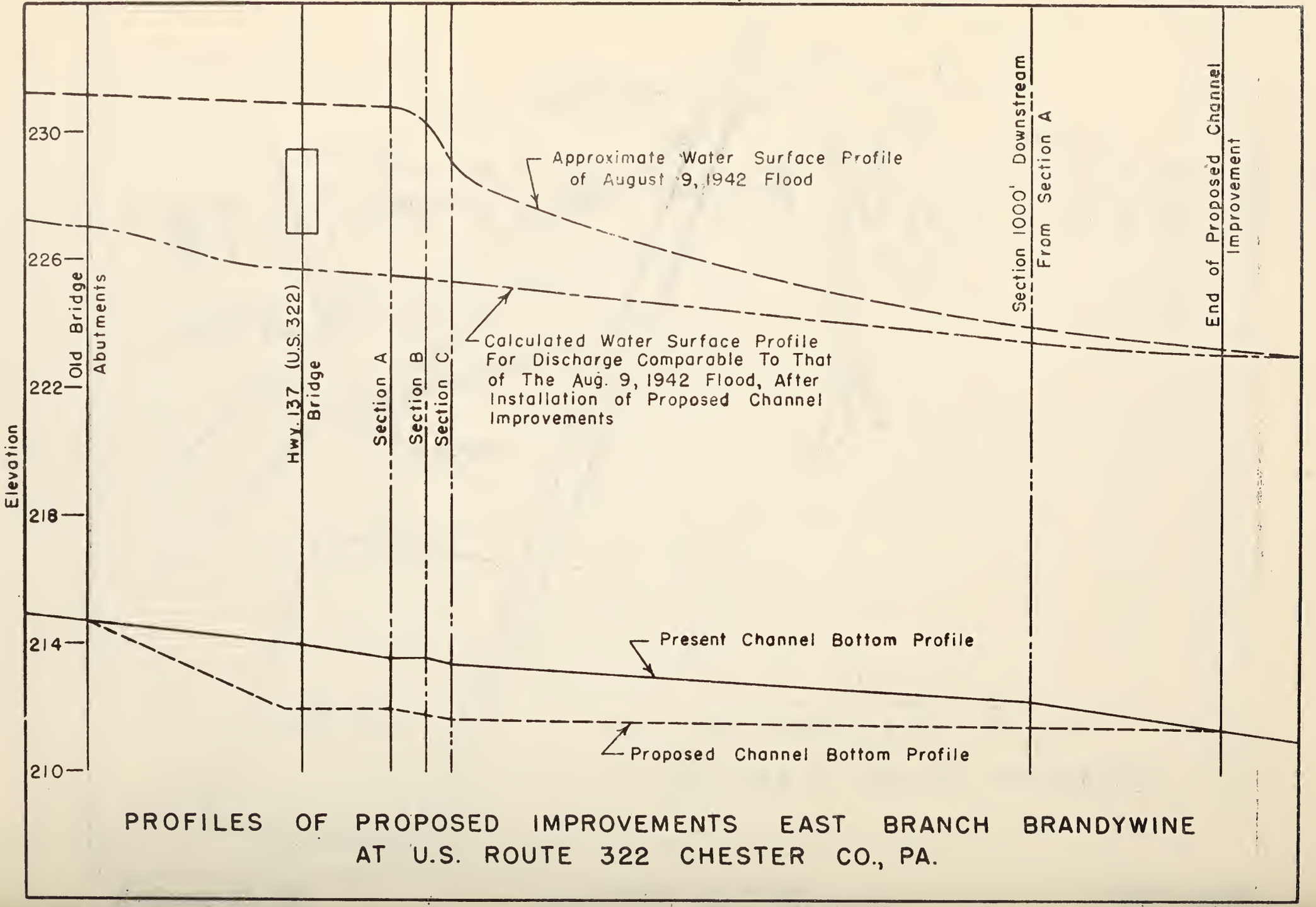
AGR-SCS-UPPER DARBY, PA JANUARY 1952

Figure 10

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ROBERT M. SALTER, CHIEF

BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR



PROFILES OF PROPOSED IMPROVEMENTS EAST BRANCH BRANDYWINE AT U.S. ROUTE 322 CHESTER CO., PA.

AGR-SCS-UPPER DARBY, PA. JANUARY 1952.

Figure 11

U. S. DEPARTMENT OF AGRICULTURE
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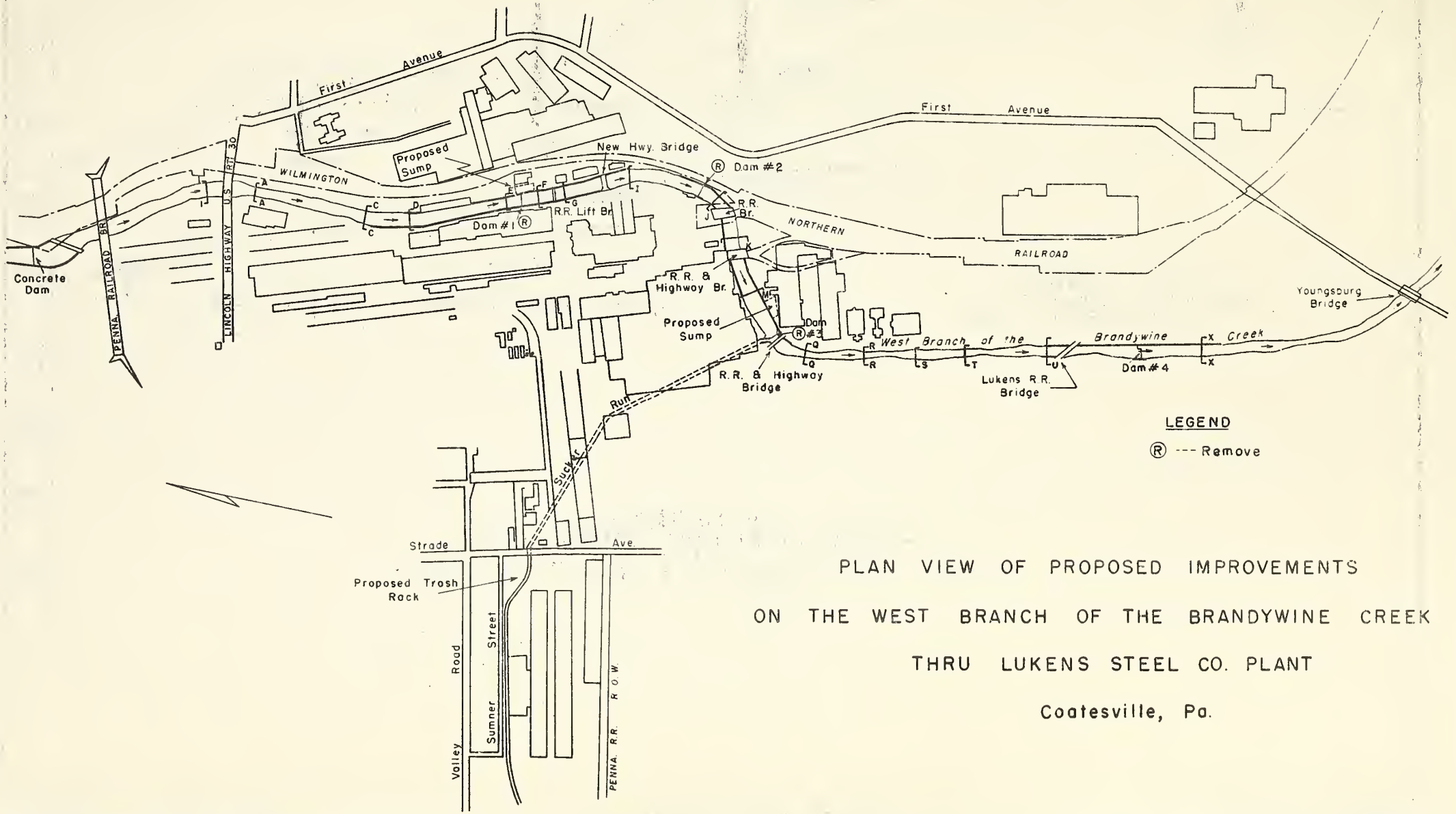
BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR



PLAN VIEW OF PROPOSED IMPROVEMENTS

ON THE WEST BRANCH OF THE BRANDYWINE CREEK

THRU LUKENS STEEL CO. PLANT

Coatesville, Pa.

AGR-SCS-UPPER DARBY, PA. JANUARY 1952

Figure 12

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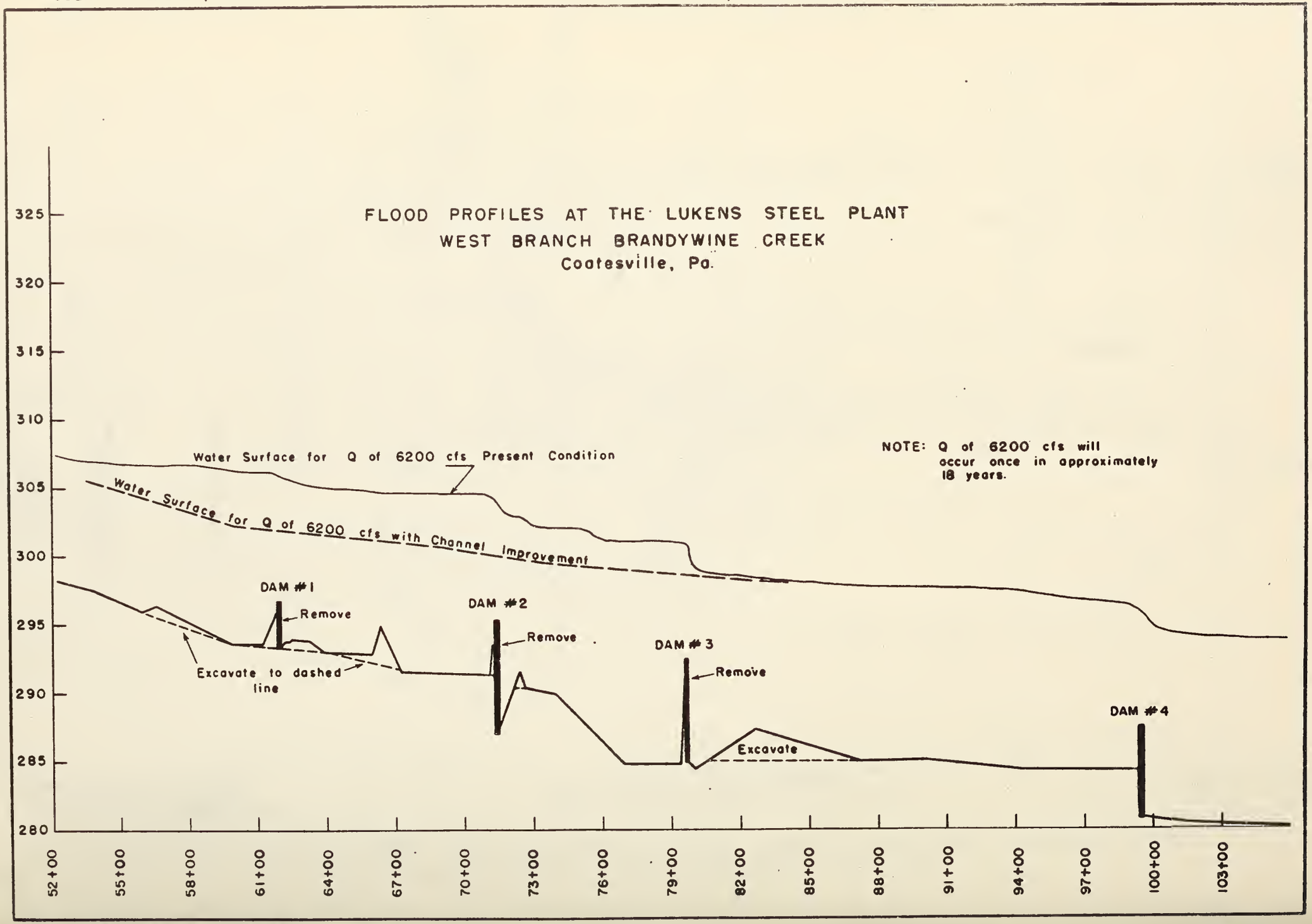
BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
AUSTIN L. PATRICK
REGIONAL DIRECTOR



AGR-SCS-UPPER DARBY, PA JANUARY 1952

Figure 13

BRANDYWINE CREEK WATERSHED
PENNSYLVANIA, DELAWARE

PLAN VIEW OF PROPOSED DIKE AT LENAPE PARK CHESTER CO., PA.

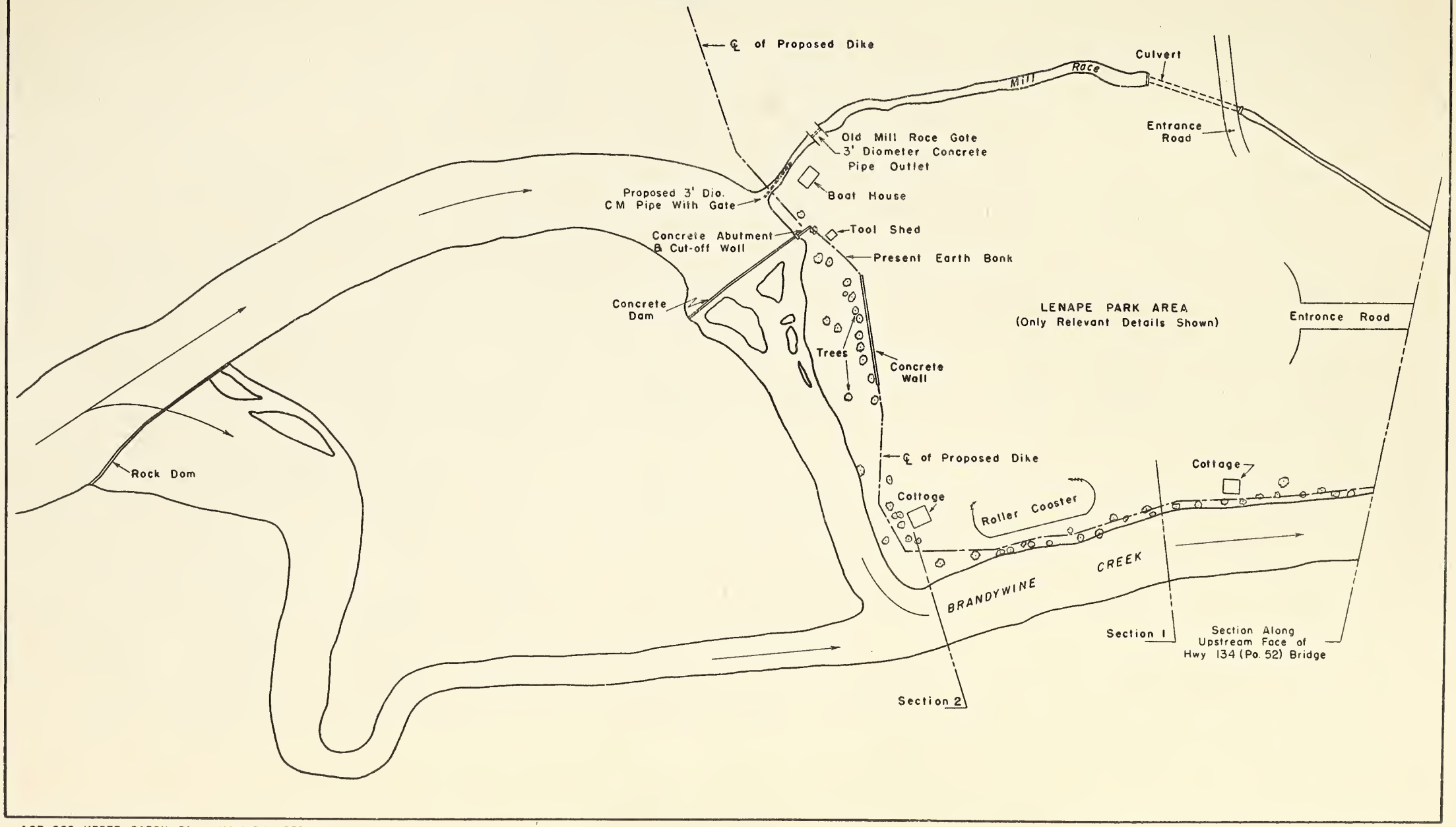


Figure 14

Table 38. Water Impoundment Sites 1/
Brandywine Creek Watershed

	Drainage Area	Pond Surface Area	Water Depth	Storage Capacity	Height of Dam	Length of Dam	Volume of Fill	Capacity-Watershed Ratio
	(sq.mi.)	(acres)	(feet)	(ac./ft.)	(feet)	(feet)	(cu.yds.)	
Coatesville	2.62	26.3	22.0	264	27.0	575	30,500	101
Lionville	0.71	31.0	28.8	333	33.6	675	36,000	469
Suplee Station	0.45	22.0	8.4	71	11.4	1,000	9,500	158
3 Mi. S.E. Cambridge	0.28	10.7	15.0	60	20	970	22,000	214
Dampman	0.15	7.8	13.5	41	17.5	1,025	21,000	273
1 Mi. S.E. Brandywine Manor	0.56	21.3	11.9	121	15.9	720	15,600	216
1 Mi. S. Brandywine Manor	0.56	22.0	8.4	48	12.4	850	5,300	86
2 Mi. W. Loag	0.58	17.8	11.4	83	16.4	1,200	21,400	143

1/ All locations listed are on the USGS Honeybrook Quadrangle Sheet.

List of Tables

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The following table indicates the unit cost of materials, labor, and use of equipment.

Table 39. Unit Costs
Brandywine Creek Watershed

Item	Unit	Cost
		(dollars)
Fence Post	Each	0.50
Farm Labor	Hour	0.83
Farm Tractor	Hour	0.65
Farm Truck	Hour	0.50
Multiflora Rose	Thousand	15.00
Straw	Ton	20.00
Power Grader (with operator)	Hour	8.00
45 H.P. Bulldozer	Hour	7.50
Stone Boat	Hour	0.50
Concrete (in place)	Cu.Yd.	110.00

The unit costs were applied to the quantities of materials, labor, and equipment required for the installation and maintenance of the various recommended measures and practices.

Benefits to Landowners

Crop and Pasture Production. The recommended conservation practices and adjustments in land use will increase the value of crop and pasture production. Value of average annual crop production and pasture will increase $511,500 and $874,500 respectively, making a total of $1,386,000.

While the acreage of clean tilled and grain crops will be reduced, value of total crop production will increase because of the larger acreage of hay and higher average yields. Average yields of clean tilled and grain crops will increase 25 percent and hay yields 32 percent.

The recommended measures for pastureland will double the present grazing value. This large increase will be produced through a net increase in acreage of 8,600, better seeding and fertility practices, mowing of weeds and mature grasses, scattering of droppings, and rotational grazing.

The above benefits from increased production were evaluated in terms of market values of the products. The value of forage was based on one-half the market value of the hay equivalent. Increased value of livestock and livestock products, which should materialize from the feeding of more grasses and hay, was not calculated.

Effect of Erosion Control on Crop and Pasture Production. Based on experimental studies, which indicate that as erosion occurs, all other production factors remaining the same, crop yields decline 5 percent with each inch of topsoil loss. The present annual rate of soil loss is 0.06 inches on cropland. Due to the program, this rate will be reduced 87 percent, creating an annual saving of 0.052 inches. This represents an incremental saving in value of crop production of $10,750 annually.

Including the benefit from erosion control on pasture, the total incremental annual saving is $11,000. The effect of the recommended program on present rates of soil erosion by major types of land use is shown in Table 40.

The rates of soil loss were applied to the acreage of corresponding land use under present and future conditions to determine the total annual loss in acre-feet, as shown in Table 41.

Table 40. Effect of Recommended Land Treatment Program on Annual Rate of Sheet and Gully Erosion by Land Use
Brandywine Creek Watershed

Land Use	Average Annual Rate of Soil Loss in Inches		Reduction in Rate of Soil Loss
	Before Planning	After Planning	
	(inches)	(inches)	(percent)
Cropland	.060	.008	87
Pasture	.005	.0005	90
Woodland	.0015	.0005	67
Idle Land	.004	.002	50
Homesteads	.0025	.0025	0

Table 41. Effect of Recommended Land Treatment Program on Sheet and Gully Erosion by Land Use Brandywine Creek Watershed

Land Use	Annual Soil Loss in Acre-Feet	
	Present	Future With Program
Cropland	361	45
Pasture	15	2
Woodland and Wildlife	6	3
Idle	14	4
Homestead, Urban, Roads	1	1
TOTAL	397	55

Woodland Production. By the improvement, protection and management measures recommended for woodlands, it is expected that the annual growth of saw timber will be increased 160 board feet per acre. Using a stumpage value of $20 per thousand board feet, the annual benefit is $3.20 per acre. For the watershed as a whole the benefit is $141,100.

Farm Pond Fish Production. Approximately 375 recommended farm ponds will be developed for fishing. The annual production of fish is estimated to be 29,200 pounds. At $0.20 per pound, the value of the annual catch is $5,800.

Crop Production Costs. Crop production costs will decrease due to the decrease in acreage of total crops. Clean tilled and grain crops will be reduced by 13,000 acres, while hay crops will be increased 8,200 acres. The changes in acreage and the shift in relative importance among types of crops will lower the annual production costs $351,500.

The recommended land treatment program, however, will require an annual expenditure of $793,859 to maintain the original investment. Thus, the net annual cost to the landowner is $442,359.

Summary of Benefits and Costs. Costs and benefits of the recommended land treatment program, as they are expected to accrue during a 20-year period, are shown in Table 42. The computation shown in this table is largely self-explanatory. The cost of operation and maintenance for the first 10 years increases until the program is completely installed, after which it is a constant.

Table 42. Costs and Conservation Benefits of Recommended Land Treatment Program
Brandywine Creek Watershed

Year	Cost of Installation	Cost of Operation & Maintenance	Interest at 4% on Accumulated Capital Invested	Total Costs	Benefit after Revision	Net Addition to Capital Invested 1/	Cumulated Capital Invested	Accumulated Net Benefit at 4% Interest
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1	411,132	-	-	411,132	-	411,132	411,132	-
2	411,132	44,236	16,445	471,813	47,229	424,584	835,716	-
3	411,132	88,472	33,414	533,018	141,689	391,329	1,227,045	-
4	411,132	132,708	49,023	592,863	283,380	309,483	1,536,528	-
5	411,132	176,944	61,315	649,391	427,582	221,809	1,758,337	-
6	411,132	221,180	70,011	702,323	574,295	128,028	1,886,365	-
7	411,132	265,416	74,824	751,372	723,519	27,853	1,914,218	-
8	411,132	309,652	75,454	796,238	875,254	(79,016)	1,835,202	-
9	411,132	353,888	71,590	836,610	1,029,500	(192,890)	1,642,312	-
10	411,132	398,124	62,906	872,162	1,186,257	(314,095)	1,328,217	-
11	-	442,359	49,066	491,425	1,345,525	(854,100)	474,117	-
12	-	442,359	13,274	455,633	1,460,074	(968,649)	-	494,532
13	-	442,359	-	442,359	1,529,905	-	-	1,074,272
14	-	442,359	-	442,359	1,553,604	-	-	1,111,245
15	-	442,359	-	442,359	1,575,892	-	-	1,133,533
16	-	442,359	-	442,359	1,596,769	-	-	1,154,410
17	-	442,359	-	442,359	1,616,235	-	-	1,173,876
18	-	442,359	-	442,359	1,634,290	-	-	1,191,131
19	-	442,359	-	442,359	1,650,934	-	-	1,208,575
20	-	442,359	-	442,359	1,666,167	-	-	1,223,808
Total	4,111,320	6,414,210	577,322	11,102,852	20,918,100			9,766,182

1/ From the eighth to twelfth years, the values indicated in parentheses represent deductions from "Capital Invested" rather than additions.

Interest on investment is computed until the accumulated annual benefits exceed the accumulated annual costs. The annual benefits increase each year because the program will continue to be installed over a 10-year period and because there is a time lag between the installation of the measures and the realization of the benefits.

Analysis of Table 42 indicates that for the watershed as a whole, 12 years after the program is started the benefits will exceed the costs of investment, interest, maintenance and operation. From the viewpoint of a lending institution the cost of the watershed land treatment program, based on its earnings, could be amortized completely within a 12-year period. The program on an individual farm will pay for itself in less than 12 years because the period of installation is shorter.

Reduction in Flood Damage

Figures 15, 16, 17, and 18 indicate graphically the reduction in flood damage. The upper curves shown in the figures in all instances indicate the flood losses under present conditions. The lower curves represent damage conditions with the improvement program in effect. The modified damage curves were prepared by considering the influence of the recommended measures on peak flood discharges and channel capacity.

Figure 15 shows the flood damage and benefits for the entire watershed while Figures 16, 17, and 18 show similar data for the 3 stream reaches where channel improvement or diking were recommended as an additional means of flood protection.

Reduction in Sedimentation

The effect of the recommended program on sedimentation in the Wilmington Harbor is shown graphically in Figure 19. Sedimentation from sheet and gully erosion and streambanks will be reduced 70 percent and 50 percent, respectively.

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BRANDYWINE CR
WATERSHED
PENNSYLVANIA, DELAWARE

NORTHEASTERN REGION
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REGIONAL DIRECTOR

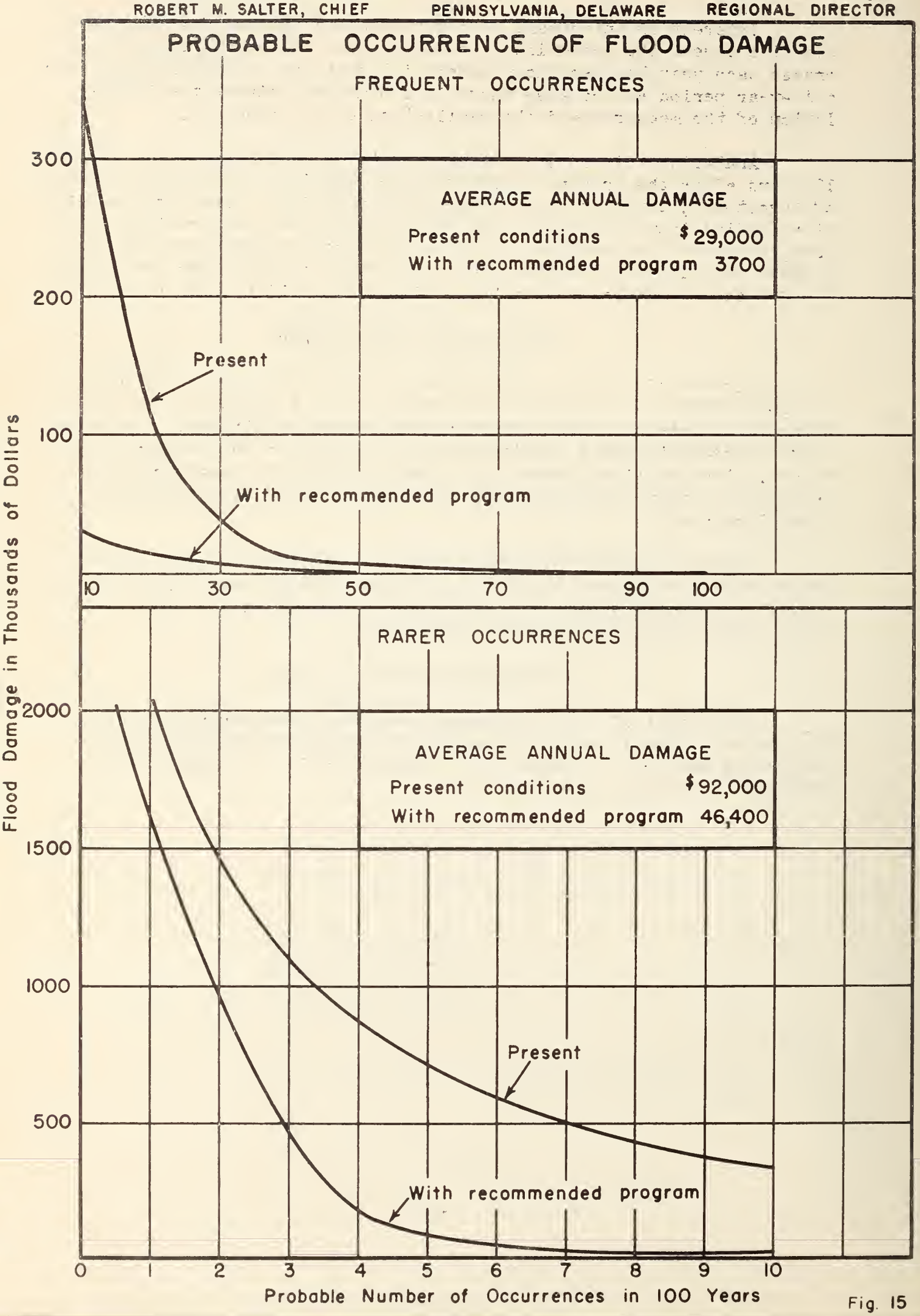

Fig. 15

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PROBABLE OCCURRENCE OF FLOOD DAMAGE

WEST BRANCH BRANDYWINE CREEK
COATSVILLE

AVERAGE ANNUAL DAMAGE	
Present conditions	$88,000
With land treatment	61,300
With land treatment and channel improvement	29,400

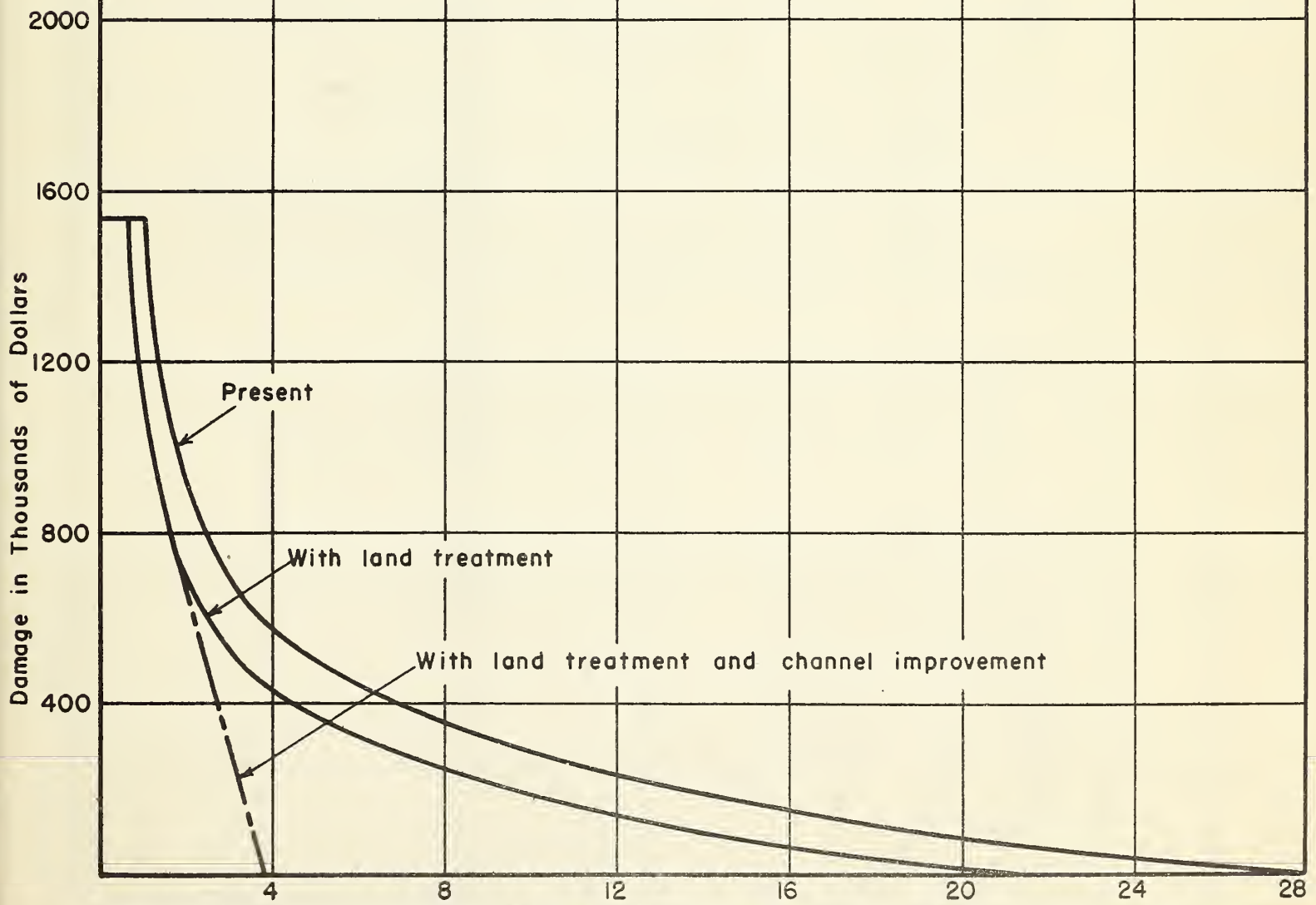

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Fig. 16

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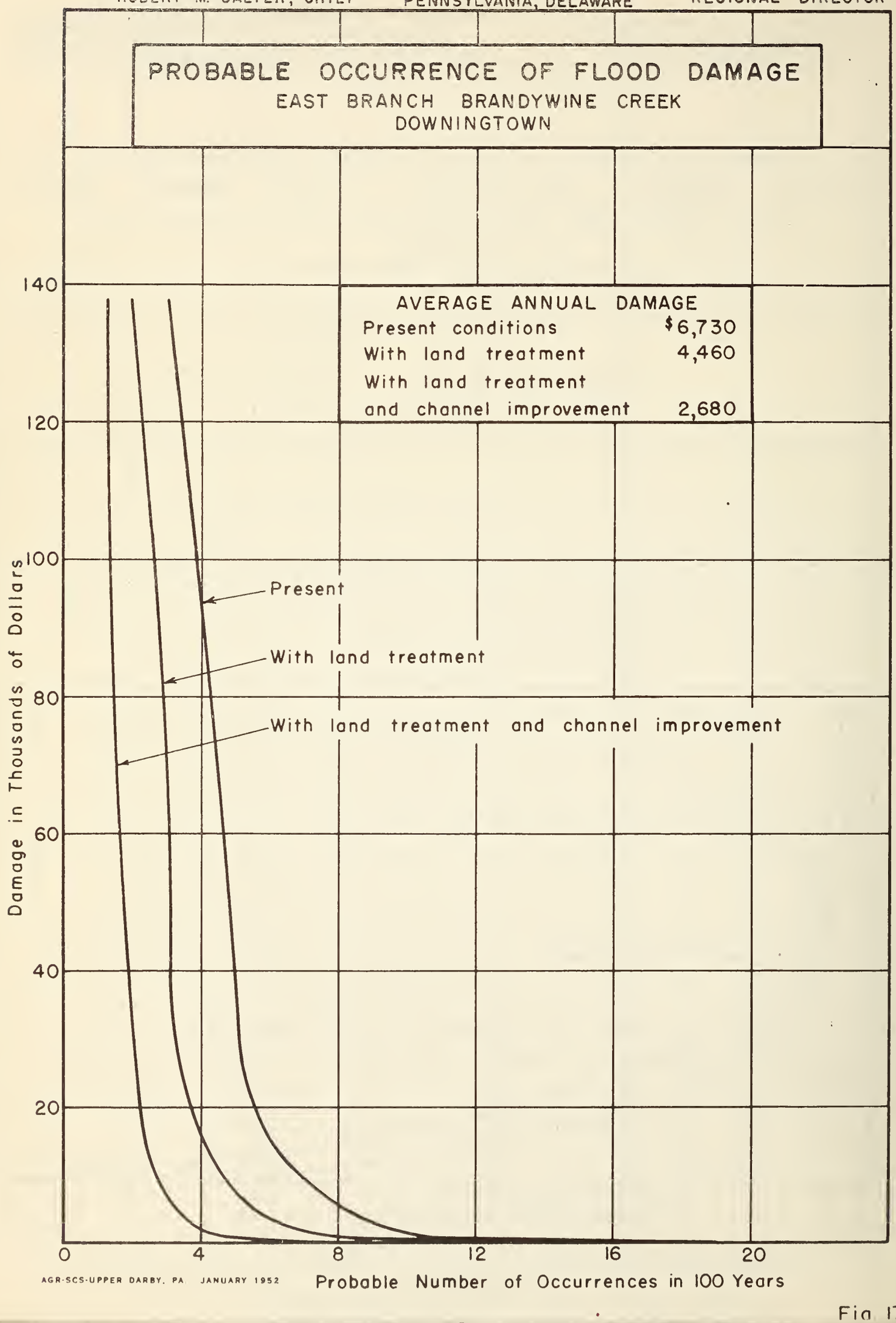

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Fig 17

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BRANDYWINE CREEK WATERSHED
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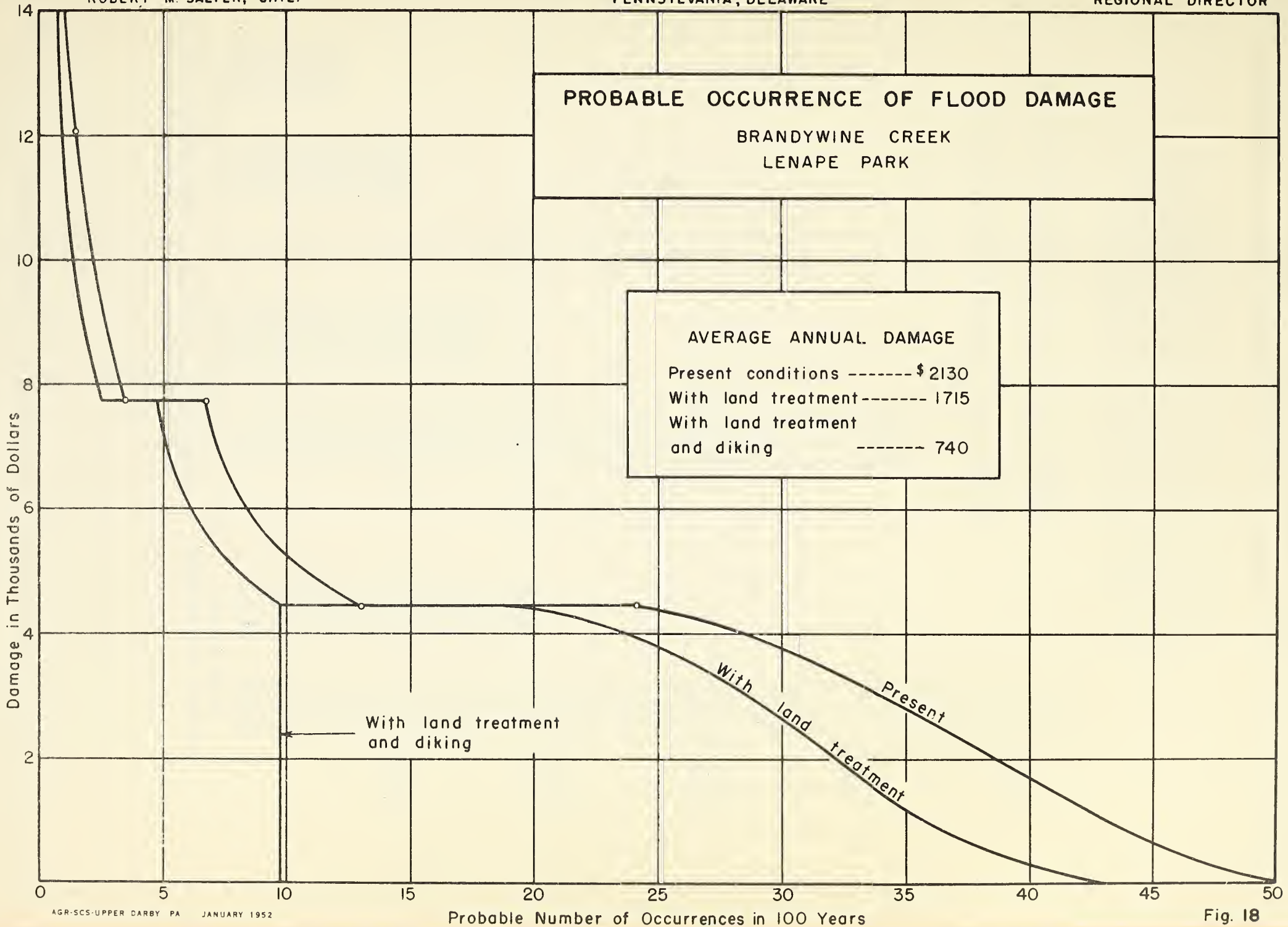

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Fig. 18

ANNUAL SEDIMENT ACCUMULATION IN WILMINGTON HARBOR DUE TO EROSION IN THE BRANDYWINE WATERSHED

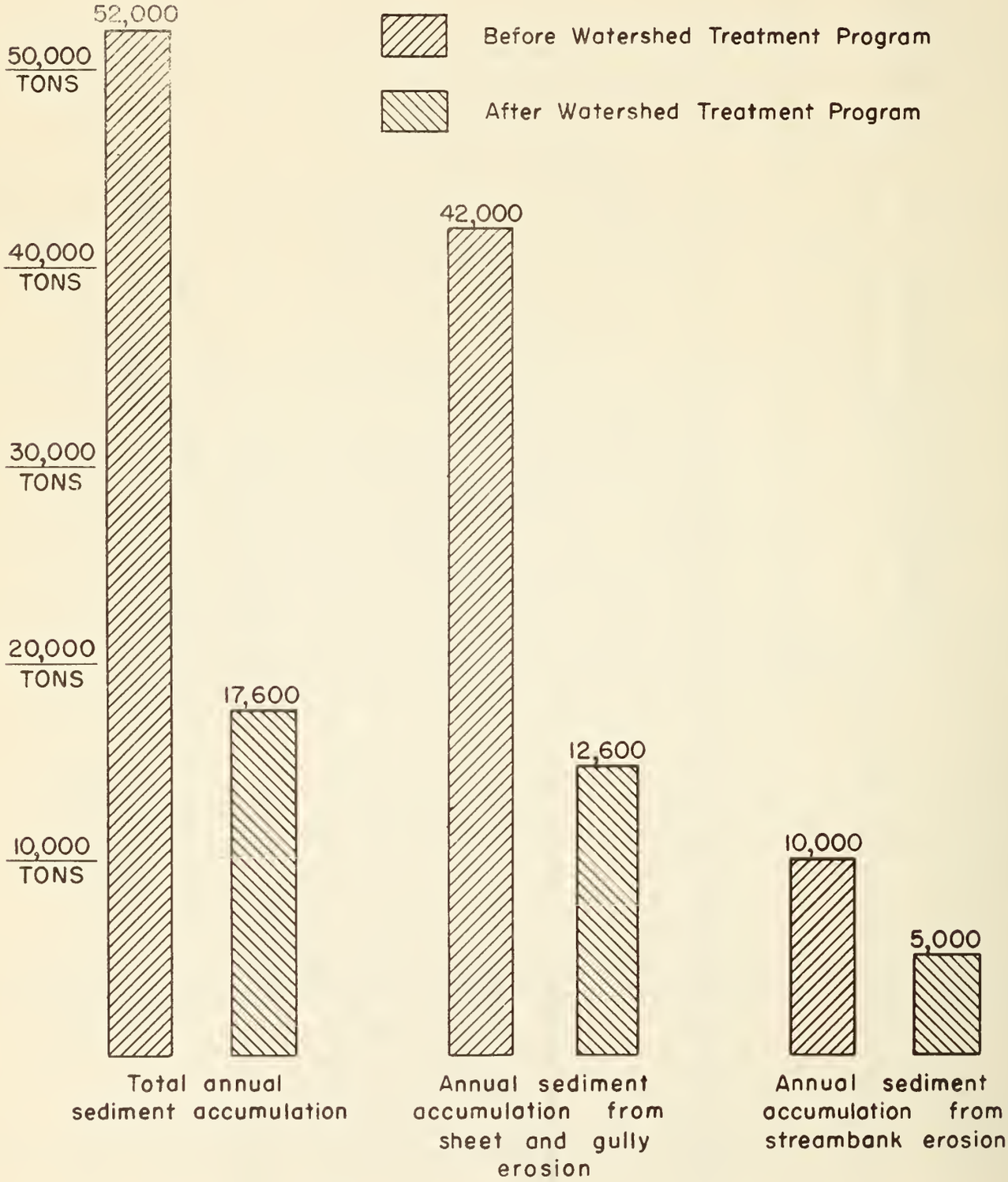

Fig. 19

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